

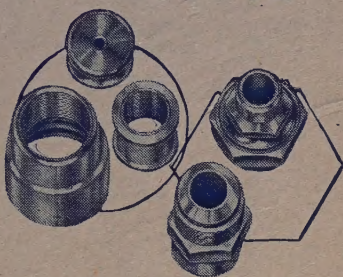
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# METALLURGICAL ABSTRACTS

(GENERAL AND NON-FERROUS)

Volume 15

MAY 1948

Part 9

## I.—PROPERTIES OF METALS

**\*Elastic Waves in Bars [Steel and Brass].** J. Howard McMillen (*Phys. Rev.*, 1946, [ii], **69**, (5/6), 250).—Brief abstract of a paper presented to the American Physical Society. A method for measuring the velocity and propagation of elastic waves in bars was found. A bar, partially immersed in water, was struck and the waves within the bar were conveyed to the water as acoustic waves. These were recorded by means of spark shadowgrams. A fast and a slow wave were observed. Their velocities relative to the velocity of sound in water were measured by making use of the angle between the water wave and the bar. The fast wave was a dilation wave travelling with a velocity characteristic of a longitudinal wave in an infinite medium; this velocity is greater than that associated with the stationary vibrations within the bar. The dilation wave velocities in cold-rolled steel and yellow brass were  $5994 \pm 34$  and  $4252$  m./sec., respectively. These velocities agreed within 2.5 and 4.0% with the calculated velocities when R. W. Vose's values for the elastic constants were used. The slow wave velocities were  $2959 \pm 79$  and  $1978$  m./sec., respectively. These velocities were 8 and 11% lower than the calculated transverse wave velocity and 4.5 and 6% lower than the calculated Rayleigh wave velocity.—AUTHOR.

**\*High-Temperature Anelastic Effects in Polycrystalline Aluminium.** (T'ing-Sui Kê). See p. 402.

**\*Effect of Grain-Size and Frequency of Measurement Upon Internal Friction and Rigidity Modulus of Aluminium.** (T'ing-Sui Kê). See p. 403.

**Beryllium, Beryllium Alloys, and the Theoretical Principles Affecting Alloy Formation with Beryllium.** (Raynor). See p. 397.

**Corrigenda: The Adiabatic Temperature Changes Accompanying the Magnetization of Cobalt in Low and Moderate Fields.** L. F. Bates and A. S. Edmondson (*Proc. Phys. Soc.*, 1948, **60**, (3), 308).—Corrections to the paper, *ibid.*, 1947, **59**, 329; see *Met. Abs.*, this vol., p. 321.—S. G.

**Germanium and Its Compounds.** A. G. Arend (*Indust. Chemist*, 1947, **23**, (265), 77–82).—A. describes the extraction of germanium and briefly discusses the properties, detection, and applications of the metal.—R. W. R.

**\*High-Voltage and Photo-Sensitive Characteristics in Germanium.** S. Benzer (*Phys. Rev.*, 1946, [ii], **69**, (11/12), 683).—Brief abstract of a paper presented to the American Physical Society. Some germanium crystal rectifiers are able to withstand high inverse voltages (as high as several hundred volts) without damage, while large currents are passed in the low-resistance direction. The back-direction characteristic is double-valued; a voltage peak occurs followed by a negative resistance region. The effects on the characteristic of temp., frequency, composition of the germanium sample and the metal electrode at the point contact, treatment of the surface and the contact, and illumination, are described. Other unusual characteristics with pronounced sensitivity to illumination and temp. were also observed in germanium

\* Denotes a paper describing the results of original research.

† Denotes a first-class critical review.

crystals: (1) a saturated  $i$ - $V$  characteristic where the saturation current varies with illumination and temp., and (2) a triple-valued characteristic exhibiting a voltage peak followed by a negative resistance region which becomes positive again at higher currents. In the latter type, illumination or increased temp. eradicates (reversibly) the voltage peak and negative resistance, leaving a single-valued curve. These photo-effects are observable with light in the visible and near infra-red, the max. sensitivity occurring at about  $1.3 \mu$ . —AUTHOR.

**\*Experiments on Contact Rectification in Germanium.** S. Benzer (*Proc. Indiana Acad. Sci.*, 1946, **56**, 236).—Brief abstract of a paper presented to the Academy. The contact rectification between metals and germanium crystals is generally explained on the natural barrier layer theory, in which the forward direction is limited by spreading resistance, while the current in the back direction is limited by a barrier layer due to the difference in work-function between the metal and the semi-conductor. If this theory applies, two pieces of the same germanium crystal when in contact with each other should show no rectification, and the current-voltage characteristic should be linear and of resistance corresponding to the spreading resistance of the contact. However, if germanium alloys of the high back-voltage type are in contact in this way, the resultant resistance is much higher than is to be expected from spreading resistance alone. This indicates that these crystals have an artificial surface layer which has a large effect on the rectification observed with a metal cat-whisker.—AUTHOR.

**\*The Photo-Diode and Photo-Peak Characteristics in Germanium.** S. Benzer (*Phys. Rev.*, 1946, [ii], **70**, (1/2), 105).—Brief abstract of a paper presented to the American Physical Society. Two photo-sensitive types of characteristic may be observed in particular germanium crystals when in contact with a metal point. In the photo-diode, the current saturates as the voltage is raised, the saturation current being sensitive to illumination and temp. The photo-current is linear with intensity and independent of voltage, identifying it as a primary photo-current. Visible and near infra-red light are effective, with threshold  $\sim 1.5 \mu$  and max. response  $\sim 1.3 \mu$ , at which latter wavelength the order of unit quantum efficiency may be obtained. The sensitivity to white light is several milli-amperes per lumen. The variation of saturation current with temp. is exponential, with an activation energy of  $\sim 0.8$  eV. In the photo-peak, the current-voltage curve has a voltage peak followed by a negative resistance which becomes positive again at higher currents. Illumination or increased temp. causes the voltage peak to be reduced, and, at sufficiently high temp. or level of illumination, the peak is eliminated. This behaviour is entirely reversible, making it useful in the design of a trigger photo-cell.—AUTHOR.

**Spontaneous Electrical Oscillations in Germanium Crystals.** S. Benzer (*Phys. Rev.*, 1947, [ii], **72**, (6), 531).—Brief abstract of a paper presented to the American Physical Society. Electric oscillations in germanium-to-metal point contacts are usually ascribable to negative resistance characteristics or mechanical effects. However, when the metal point is placed at the edges of regions showing the photo-diode effect (*Phys. Rev.*, 1946, [ii], **70**, 105; see preceding abstract), strong oscillations of an apparently different nature occur in a circuit containing only a D.C. source and a resistance in series with the crystal. Above a critical voltage (for one polarity only), oscillations begin; the frequency increases from the order of  $10^5$  c./s. at several volts to  $10^6$  c./s. at higher voltages and is insensitive to external circuit resistances. The amplitude may approach the supply voltage and the wave-form is usually non-sinusoidal. The frequency and amplitude are strikingly sensitive to illumination and temp. For a contact at the edge of a photo-diode region, one would expect to find a thin "sandwich" of  $N$ -type germanium between metal and



*P*-type germanium. Such a configuration would have a minimum in the potential of an electron which might lead to oscillations. R. Bray has recently observed similar oscillations with suitably etched *P*-type germanium crystals.

—AUTHOR.

**\*Properties of *P*-Type Germanium Rectifiers.** Ralph Bray and K. Lark-Horovitz (*Proc. Indiana Acad. Sci.*, 1946, **56**, 236).—Brief abstract of a paper presented to the Academy. The unit consisting of a pointed metal wire making contact with a *P*-type (hole-conducting) germanium has rectifying, photo-voltaic, photo-conductive, and thermal properties, which depend on the particular metal used, and the resistivity and surface treatment of the germanium crystal. Shining light near to the metal-germanium contact greatly increases the current in the high-resistance direction (metal positive, germanium negative), but produces little change in the conducting direction. This effect may be so pronounced as to make it appear that the rectification is reversed. Heating the unit produces a similar effect, the higher the resistivity of the sample the lower the temp. at which reversal takes place. Unlike the photo-effect, the thermal effect is quite insensitive to what metal is used. The photo-effects are most sensitive to the infra-red portion of the spectrum. The large increase in current produced by heat and light is probably due to the excitation of electrons from the full band of the germanium semi-conductor into the empty band. The energy necessary for such excitation corresponds to the frequency and temp. at which these effects occur. However, the great difference in magnitude between the effects in the low- and high-resistance directions cannot be explained by the simple theory of a natural barrier between semi-conductor and metal.—AUTHORS.

**\*Spreading-Resistance Discrepancies and Field Effects in Germanium.** Ralph Bray, K. Lark-Horovitz, and R. N. Smith (*Phys. Rev.*, 1947, [ii], **72**, (6), 530).—Brief abstract of a paper presented to the American Physical Society. Contact and spreading resistance determine the forward resistance of metal-germanium point-contact rectifiers. Theoretically, the spreading resistance is  $\rho/2d$ ;  $\rho$  = semi-conductor resistivity and  $d$  = contact diameter. Above 1 V., the contact-resistance contribution is negligible, and the spreading resistance is then given by the slope of the current-voltage characteristic curve. However, the spreading resistance so determined on high-resistivity ( $\rho \sim 1$  ohm-cm.) *N*-type germanium decreases with increasing voltage and is lower by factor ten or more than the value predicted from bulk resistivity. The high c.d. through the contact ( $\sim 10$  m.amp. through  $10^{-6}$  cm.<sup>2</sup>) suggest the possibility of field effects. Actually, the bulk resistivity (studied with exponential and const. current pulses) is field-dependent and starts to decrease at fields of 100 V./cm. The time constant of the field effects may be estimated from the progressive increase of spreading resistance with frequency (about 100 kc./s.). Calculations were made relating at least qualitatively the spreading-resistance discrepancies with field-dependence measurements of bulk resistivity.

—AUTHORS.

**Theory of Impurity Scattering in [Germanium] Semi-Conductors.** C. Conwell and V. F. Weisskopf (*Phys. Rev.*, 1946, [ii], **69**, (5/6), 258).—Brief abstract of a paper presented to the American Physical Society. Recent experiments on Hall effect and resistivity of germanium conductors have shown that the simple theory of lattice scattering alone cannot explain the temp. dependence of mobilities. Another obvious source of resistance is scattering by impurity centres, such as Rutherford scattering of electrons (or holes) by a random distribution of impurity ions. Because of the large wavelength of these thermal electrons, their movement can be considered as free, and their scattering by the impurity ions is given by the classical expression, assuming perfectly elastic collisions and effectively infinite mass for scattering centres. Scattering of an electron by one ion is treated as approx. in-

dependent of all other ions. The resistivity due to such impurity scattering is (in ohm-cm.)

$$\rho = \frac{9 \times 10^{11} \pi^{3/2} e^2 m^{1/2}}{2^{7/2} \kappa^2 (kT)^{3/2}} \ln \left( 1 + \frac{36 \kappa^2 k^2 T^2 d^2}{e^4} \right),$$

where  $d$  is half the average distance between impurity ions and  $\kappa$  the dielectric constant of the semi-conductor.—AUTHORS.

**\*Theory of Thermo-Electric Power in Germanium.** V. A. Johnson and K. Lark-Horovitz (*Phys. Rev.*, 1946, [ii], **69**, (5/6), 259).—Brief abstract of a paper presented to the American Physical Society. Thermo-electric power  $Q$  in semi-conductors was calculated under conditions of simultaneous conduction by positive and negative conductors. The low-temp. form (impurity conduction only) becomes  $Q = (\ln RT^{3/2} - 5.32)k/e + \Delta Q$ , where  $R$  is the Hall constant in cm.<sup>3</sup>/coulomb and  $\Delta Q$  is a term to compensate for the dependence of mean free path on velocity. In general:

$$Q = -\frac{k}{e} \left[ 38.121 \frac{n_1 c - n_2}{n_1 c + n_2} - 0.659 \frac{n_2}{n_1 c + n_2} - \frac{n_1 c}{n_1 c + n_2} \ln \left( \frac{n_1}{T^{3/2}} \right) + \frac{n_2}{n_1 c + n_2} \ln \left( \frac{n_2}{T^{3/2}} \right) \right]$$

where  $n_1$  and  $n_2$  are the number of electrons and holes per c.c., determined from conductivity, and  $c$  is the ratio of electrons and hole mobility in the intrinsic range, identical for all germanium samples. The thermo-electric power thus calculated is in agreement with experiment throughout the temp. range.

—AUTHORS.

**\*Contact Capacity of Crystal Rectifiers [Germanium].** R. N. Smith (*Phys. Rev.*, 1946, [ii], **69**, (11/12), 683).—Brief abstract of a paper presented to the American Physical Society. The capacity across the rectifying point contact formed at a metal-semi-conductor interface has been measured by an indirect method for germanium and silicon mixer crystals. The decrease in efficiency of rectification as the frequency is increased to very high (micro-wave) frequencies is used to calculate the capacity. Two assumptions are made: (1) crystal rectifiers may be represented by a non-linear contact resistance in parallel with the contact capacity, both in series with a fixed "spreading" resistance; and (2) the resistance elements of the rectifier model are independent of frequency. The contact capacity was measured as a function of D.C. bias voltage between + and -1 V. bias. For silicon units the capacity increased slowly at first, as the bias was increased in the forward (low-resistance) direction, increasing more rapidly as the voltage across the contact approached the contact potential of the metal-semi-conductor. This behaviour is in qualitative agreement with that predicted for a rectifying contact of the "natural barrier" type. For germanium units, however, the increase in capacity with forward-bias voltage was much greater. This discrepancy is great enough to necessitate modification of the simple model and/or the theory of rectification for germanium.—AUTHOR.

**\*Effect of Various Atmospheres on Germanium Crystal Rectifiers.** R. M. Whaley and K. Lark-Horovitz (*Phys. Rev.*, 1946, [ii], **69**, (11/12), 683).—Brief abstract of a paper presented to the American Physical Society. Quantitative measurements of voltage-current characteristics were made for point contacts on various germanium samples prepared in a high vacuum ( $\sim 3 \times 10^{-6}$  mm. mercury), tested in a vacuum, and after admission of gases at various pressures. Samples fall into 3 classes: (a) relatively high-purity germanium which provided poor rectification in a vacuum and was unchanged by admission of gas; (b) one sample which showed reversible changes on admission of air; and (c) samples of relatively high conductivity, due to impurity, which provided good rectification *in vacuo* and showed



irreversible increases in back resistance by factors of 10–1000 on admitting air. Similar changes, usually to a smaller extent, followed admission of nitrogen. Observed changes can be accounted for, using the multi-contact theory, by assuming the removal of very small areas of low positive contact potentials, either by covering them with insulating layers or by converting them into regions of higher positive contact potential. On highly conducting samples, irreversible increases in back resistance were most pronounced at low voltages, but increases did extend to the voltage peak. The peak voltage sometimes was increased by admission of air, usually by factors less than 2.

—AUTHORS.

**\*Theory of Resistivity in Germanium Alloys.** (Lark-Horovitz and Johnson). See p. 399.

**\*Electrical Properties of Germanium Alloys. I.—Electrical Conductivity and Hall Effect.** (Lark-Horovitz, Middleton, Miller, and Wallerstein). See p. 399.

**\*Electrical Properties of Germanium Alloys. II.—Thermo-Electric Power.** (Lark-Horovitz, Middleton, Miller, Scanlon, and Wallerstein). See p. 399.

**D.C. Characteristics of Germanium and Silicon Crystal Rectifiers.** H. J. Yearian (*Phys. Rev.*, 1946, [ii], **69**, (11/12), 682).—Brief abstract of a paper presented to the American Physical Society. Current theories of crystal rectification predict currents in the low-resistance (forward) direction, which rise exponentially with the voltage across the contact for  $V \gg e/kT$ , and which approach a saturation current in the high-resistance direction. In  $i$  versus  $V$ , plots for the forward direction should have a slope  $\alpha = e/kT = 40 \text{ V}^{-1}$  at  $300^\circ \text{ K}$ . Characteristics of germanium and silicon rectifiers usually have an exponential behaviour, but  $\alpha$  is always less than  $e/kT$ , frequently between  $\frac{1}{2}$  and  $\frac{2}{3}$  of this value. The current in the back direction has a saturation component but also an ohmic component, and a rapidly increasing “tail” at higher voltages. More elaborate theories which include the effects of image forces in lowering the barrier, and of penetration of the barrier, give logarithmic slopes less than  $e/kT$  and a “tail” in the back direction. However, such corrections cannot explain the values of  $\alpha$  most frequently found without eliminating at the same time the conditions necessary for rectification.—AUTHOR.

**Theory of Crystal Rectifiers [Germanium and Silicon].** R. G. Sachs (*Phys. Rev.*, 1946, [ii], **69**, (11/12), 682).—Brief abstract of a paper presented to the American Physical Society. The observed D.C. current-voltage characteristics for point contacts between metal and semi-conductor (germanium and silicon) cannot be explained by the diffusion of electrons through a blocking layer at the contact. The ordinary diode theory predicts a characteristic with too steep a slope in the forward direction. Consideration of tunnel effect and the effect of positive space charge does not produce agreement. The multi-contact theory, introduced to explain the observed characteristics, assumes that (1) the contact potential  $\phi$  varies continuously over the surface of the contact; (2) the total current is the sum of the partial currents flowing through regions of varying  $\phi$ ; (3) the area of a region with a contact potential  $\phi$  may be a function of  $\phi$ ; and (4) the number of spots having contact potential between  $\phi$  and  $\phi + d\phi$  is a function of  $\phi$ . A Gaussian distribution of  $\phi$  values is assumed. Correction is made for the effect of the image force. Characteristics calculated under these assumptions approximately agree with the observed characteristics.—AUTHOR.

**Semi-Quantitative Explanation of D.C. Characteristics of Crystal Rectifiers [Germanium and Silicon].** V. A. Johnson, R. N. Smith, and H. J. Yearian (*Phys. Rev.*, 1946, [ii], **69**, (11/12), 682).—Brief abstract of a paper presented to the American Physical Society. The multi-contact theory is employed to explain the observed D.C. current-voltage characteristics for contacts between metal and semi-conductor (germanium and silicon). The area of each spot

having contact potential  $\phi$  and the number of spots having contact potential between  $\phi$  and  $\phi + d\phi$  are assumed to be exponential functions of  $\phi$ . The parameters of these functions may be determined from measured values of the limiting current in the back direction, the back resistance, and the intercept at zero applied voltage of the forward current. Current limitation is introduced so that the c.d. does not exceed the max. c.d. carried by  $N$  electrons/cm.<sup>3</sup> (known from Hall effect) moving with thermal velocity. The proper slopes are obtained for the forward current. The variation of characteristic with temp. change can be explained by assuming a corresponding change in distribution of  $\phi$  values. A graphical method of applying the multi-contact theory has been developed.—AUTHORS.

**Small Deviations from Diode Behaviour in Crystal Rectification.** K. F. Herzfeld (*Phys. Rev.*, 1946, [ii], 69, (11/12), 683).—Brief abstract of a paper presented to the American Physical Society. The blocking layer in a crystal rectifier may be treated according to diode theory if the mean free paths of electrons are very large compared to the dimensions of the blocking layer, so that no collisions occur. The diffusion theory assumes a mean free path very small compared to the thickness of the blocking layer. To get a better insight into the behaviour of the electrons, it has been assumed that the mean free path is large, but not infinitely large compared with the thickness of the blocking layer, so that some collisions occur, but multiple scattering can be neglected. It is assumed that "collision" means absorption and re-evaporation. Simple formulæ derived from these assumptions give less dependence of the current on voltage than in pure diode theory, but the effect is very small.—AUTHOR.

**\*Image Force and Tunnel Effect in Crystal Rectifiers.** E. D. Courant (*Phys. Rev.*, 1946, [ii], 69, (11/12), 684).—Brief abstract of a paper presented to the American Physical Society. According to elementary theory, the current through a rectifying junction between a metal and a semi-conductor should vary with the applied voltage  $U$ , according to:

$$i = i_0 \left[ \exp \left( -\frac{V_c - U}{kT} \right) - \exp \left( -\frac{V_c}{kT} \right) \right] \quad (1)$$

where  $V_c$  is the contact potential and  $V_c - U$  the height of the potential barrier. Experimentally, it is found that  $i$  increases with  $U$  less rapidly than is indicated by (1), for positive  $U$ , and  $|i|$  increases with increasing negative  $U$  instead of tending to a const. value, as indicated by (1). Both these effects may be explained by assuming that the height of the potential barrier is reduced by the image force and that some electrons tunnel through the barrier near its top. As a result of these two effects, the potential barrier is in effect reduced to  $\theta(V_c - U)$ , where  $\theta < 1$ , and (1) must be multiplied by  $\exp \left[ - (1 - \theta) \frac{V_c - U}{kT} \right]$ . Graphs of  $\theta$  as a function of  $U$  are shown in the

paper and compared with experimental measurements.—AUTHOR.

**\*The Poisoning of Oxide Cathodes by Gold.** Jerome Rothstein (*Phys. Rev.*, 1946, [ii], 69, (11/12), 693).—Brief abstract of a paper presented to the American Physical Society.

**\*Thermal Conductivity of Metals at High Temperatures. I.—Description of the Apparatus and Measurements on Iron.** L. D. Armstrong and T. M. Dauphinee (*Canad. J. Research*, 1947, [A], 25, (6), 357-374).—A. and D. describe an apparatus for measuring the thermal conductivity of metals in the temp. range 0°-800° C. The cylindrical specimen has a heater attached at one end and a heat sink at the other; the specimen is enclosed by a heated guard tube and heated caps, and the entire apparatus is enclosed in a chamber ("pyrostat") evacuated to a pressure of less than 1  $\mu$  mercury. The central



portion of the evacuated chamber, which contains the specimen, is heated by a cylindrical furnace. Temp. are measured at points 5 cm. apart along the length of the specimen, the heat flow in which is assumed to be uni-directional; platinum/platinum-rhodium thermocouples are used. The conductivity of the sample is calculated from the measurable heat input and from the temp.-gradient measurements. The errors of the method are discussed, and it is concluded that the absolute error is  $>2\%$ , with relative error  $<1\%$ . The apparatus was used to determine the conductivity of Armco iron, and values of 0.181, C.G.S. ( $0^\circ\text{C.}$ ) and 0.069, C.G.S. ( $800^\circ\text{C.}$ ) were obtained, which values agree well with the results of other determinations. The conductivity-temp. curve shows a discontinuity at about  $375^\circ\text{C.}$ , which is ascribed to the presence of 0.03% nickel.—R. W. R.

**\*Kinetics of Hydrogenation and of Related Reactions. I.—The Mechanism of Hydrogenation, Dehydrogenation, and Deuterium Exchange. II.—Kinetics of Hydrogenation with Nickel, Platinum, and Copper. III.—Selective Hydrogenation.** A. Balandin (*Acta Physicochim. U.R.S.S.*, 1947, 22, (1), 81–100, 101–120; (2), 338–356).—[In English]. (I.—) A new theory of hydrogenation is advanced. (II.—) The kinetics of hydrogenation on nickel, platinum, and copper are treated from the point of view of the new theory of hydrogenation. The theory agrees with the facts, many of which could not be accounted for by previous theories. (III.—) The new theory is applied to the catalytic hydrogenation of mixtures.—S. G.

**\*The Surface Impedance of Supraconductors and Normal Metals at High Frequencies. I.—Resistance of Supraconducting Tin and Mercury at 1200 Mc./s.** A. B. Pippard (*Proc. Roy. Soc.*, 1947, [A], 191, (1026), 370–384).—The technique of resonator measurements at 1200 Mc./s. is described in detail, and experimental curves are given showing the variations with temp. of the resonator frequency resistivity of supraconducting tin and mercury. Unlike the behaviour of supraconductors in static fields, a finite resistance is present at all temp., tending, as absolute zero is approached, to a very low value, which is probably zero for mercury but not for tin. Where  $R$  is the resistivity at any temp. and  $R_n$  is the resistivity of the normal metal just above the transition point, the values are: (1) for mercury  $100R/R_n = 100$  at  $4.1525^\circ\text{K.}$  and  $0.05$  at  $2.20^\circ\text{K.}$ ,  $R_n$  being  $2.34 \times 10^{-3} \Omega$  at  $4.2^\circ\text{K.}$ , and (2) for tin  $100R/R_n = 100$  at  $3.712^\circ\text{K.}$  and  $0.8$  at  $1.83^\circ\text{K.}$ ,  $R_n$  being  $1.50 \times 10^{-3} \Omega$  at  $3.8^\circ\text{K.}$  Thus, confirming previous observations for tin, the resonator frequency resistance is much greater than that predicted from the classical skin-effect theory, and a similar though less-marked effect is found for mercury.—E. N.

**\*The Surface Impedance of Supraconductors and Normal Metals at High Frequencies. II.—The Anomalous Skin Effect in Normal Metals [Silver, Gold, Tin, Aluminium, Copper, Mercury].** A. B. Pippard (*Proc. Roy. Soc.*, 1947, [A], 191, (1026), 385–399).—Cf. preceding abstract. Using methods previously described, it is shown that at low temp. the resonator frequency skin conductivity of the normal metals silver, gold, and tin tends to become independent of the D.C. conductivity, which is at variance with the predictions of the classical skin-effect theory. This anomalous behaviour is shown to be due to the mean free path ( $l$ ) of the electrons becoming much greater than the skin depth ( $\delta$ ) (for silver  $l = 4.4 \times 10^{-4} \text{ cm.}$  and  $\delta = 5.2 \times 10^{-5} \text{ cm.}$ ) and also to the fact that under these conditions only a small proportion of the conduction electrons, namely those which suffer collision in the surface layer containing the electric field, contribute effectively to the H.F. current. Values for the mean free path in copper, gold, aluminium, and tin relative to the value in silver are calculated from the experimental results and are not in good agreement with the theoretical estimations of other workers. The behaviour of mercury is different from that of other metals investigated, in that the

resonator frequency skin conductivity does not tend to a const. value as the anomalous skin effect appears at such temp. that the ideal resistance is still many times greater than the residual resistance.—E. N.

**\*The Surface Impedance of Supraconductors and Normal Metals at High Frequencies. III.—The Relation Between Impedance and Supraconducting Penetration Depth.** A. B. Pippard (*Proc. Roy. Soc.*, 1947, [A], **191**, (1026) 399–415).—Cf. preceding abstract. The theory that the difference between the values calculated by the classical skin-effect theory and measured values of the surface resistivity of normal metals and supraconductors at low temp. and at frequencies around 1200 Mc./s. is due to the fact that only those electrons are effective in the conduction process which are at glancing angles to the surface, is applied to H. London's (1940) model of a supraconductor, and a formula is derived relating the resonator frequency resistivity to the supraconducting penetration depth and other parameters of the metal. It is shown how the penetration depth may be deduced directly from measurements of the skin reactance, and a method of measuring reactance is described. The method has been applied to mercury and tin, and in the former case the results are in agreement with Shoenberg's direct measurements, and confirm that the penetration depth at 0° K. is of the order of  $7 \times 10^{-6}$  cm. The results are discussed with special reference to the theory of supraconductivity developed by Heisenberg, who has shown how the Coulomb interaction between the conduction electrons may lead at low temp. to a thermodynamically more favourable state in which the electrons at the top of the Fermi distribution are formed into wave-packets which may be propagated through the metal without resistance, and may therefore be regarded as supraconducting electrons. It seems likely that as the absolute zero is approached more and more electrons will undergo this "condensation", but that even at 0° K. not all the conduction electrons will be supraconducting. This does not mean, however, that the normal conductivity will persist at all temp., since the condensed wave-packets must occupy regions at the surface of the electron distribution in phase space, and render these regions inaccessible to the uncondensed normal electrons through the operation of Pauli's Exclusion Principle.—E. N.

**\*The Plastic Deformation of Zinc as a Function of Strain Rate.** Solomon Lasof (*Phys. Rev.*, 1946, [ii], **69**, (11/12), 687).—Brief abstract of a paper presented to the American Physical Society. L. investigated the influence of rate of strain on the plastic behaviour of single crystals of high-purity zinc deformed by compression at const. strain rates of relative magnitude  $1.08 \times 10^7 : 81 : 9 : 1$ . The highest strain rate studied corresponds to an impact velocity of 690 cm. sec.<sup>-1</sup>. Room-temp. stress-strain, or load-compression, curves were obtained for single-crystal specimens of various orientations and for polycrystal specimens having a grain-size of about 2 mm. All specimens were right circular cylinders 9.5 mm. long and 4.75 mm. in dia. The direction of compression was along the cylinder axes. For favourably oriented single crystals, varying the speed of deformation had little or no effect for the three relatively low strain rates studied. Definite evidence for a speed effect was found for the high strain rate. Polycrystals and unfavourably oriented single crystals showed no speed effect for relatively small deformations, but a marked effect was observed for larger deformations throughout the range of strain rates studied.—AUTHOR.

**General Stress-Strain Laws of Elasticity and Plasticity.** A. Gleyzal (*J. Appl. Mechanics*, 1946, **13**, (4), A261–264).—The stress-strain laws discussed by G. apply to problems where the material is elastic in some regions and plastic in others, e.g. in a plastic-torsion problem or in a plastic-bending problem. These laws have experimental verification for metals in cases where strains are small and stresses and strains are either monotonically increasing or monotonically decreasing at any one point.—AUTHOR.



**\*A Connection Between the Criterion of Yield and the Strain-Ratio Relationship in Plastic Solids.** (Sir) Geoffrey Taylor (*Proc. Roy. Soc.*, 1947, [A], 191, (1027), 441–446).—Assuming that the work done during a small plastic strain is a maximum as the yield-stress criterion is varied, it is shown that there is a connection between the yield stress and the strain-ratio relationship. The strain-ratio relationship is that which exists between the ratios of principal stress differences and the ratios of the corresponding strain differences. Although it is common to assume that this relationship is one of simple proportionality, experiments show that this assumption is not true in metals. The observed strain-ratio relationship is used in conjunction with the assumption of max. work during a given strain to calculate the criterion of yield. When applied to copper tubes subjected to combined end-load and torsion, this criterion is found to be very close to, but not identical with, the Mises-Hencky criterion; it is different to that of the max. stress-difference criterion of Mohr.—E. N.

**The Importance of Ultimate Extension as an Engineering Property of Materials.** A. Fisher (*Magnesium Rev. and Abs.*, 1947, 7, (1), 3–17).—Reprinted from *Metallurgia*, 1946, 34, (200), 77–84; see *Met. Abs.*, 1946, 13, 283.—J. L. T.

**The Dependence of the Diffusion Coefficient on Concentration.** B. Serin (*Phys. Rev.*, 1946, [ii], 69, (11/12), 687).—Brief abstract of a paper presented to the American Physical Society. It is assumed that the activation energy for the diffusion of foreign atoms in a solid lattice depends on the surrounding number of nearest-neighbour foreign atoms. For equal *a priori* probabilities for the formation of different foreign-atom configurations in the lattice, the diffusion coeff.  $D$  is

$$D = \delta^2 \sum_{a_i=0}^a q_{ai} \left\{ \frac{a! (a_i + 1)}{(a - a_i)! a_i!} \left[ 1 - \frac{(a + 1)}{(a_i + 1)} f \right] f a_i (1 - f)^a - a_i - 1 \right\}.$$

$q_{ai}$  is the probability that a foreign atom with  $a_i$  other foreign atoms as nearest neighbours will make a jump in the lattice,  $a$  is the total number of nearest neighbours,  $\delta$  is the interatomic spacing, and  $f$  is the fractional atomic concentration of foreign atoms. The statistical terms in the bracket in the expression above change very rapidly with  $f$ . While the detailed dependence of  $D$  on concentration is determined by the relative magnitudes of the  $q_{ai}$ , it would seem that this dependence is conditioned in large part by the statistical terms.—AUTHOR.

**Dissociation Pressures of Metal Oxides Formed on Various Solid Metals.** Benjamin Lustman (*Steel Processing*, 1946, 32, (10), 669, 676).—Curves are reproduced for the dissociation pressures of most common metal oxides as a function of temp.—J. C. C.

**\*Surfaces of Solids. XIV.—A Unitary Thermodynamic Theory of the Adsorption of Vapours on Solids and of Insoluble Films on Liquid Sub-Phases.** George Jura and William D. Harkins (*J. Amer. Chem. Soc.*, 1946, 68, (10), 1941–1952).—This investigation was commenced with the following idea as a basis: the general phase relations of adsorbed films on solids should be essentially the same as those of mono-layers of oil on water. This expectation is shown to be justified by the relations listed below: (1) On compression of an oil film on water, the succession of phases is (a) gas, (b) liquid expanded, (c) liquid intermediate, (d) liquid condensed, and (e) higher pressure condensed. The same succession is found in films on solids. (2) Except for the gaseous state, no valid equations of state for films had been developed prior to the work of J. and H., who have obtained empirical equations given in the paper. The remarkable feature revealed by the experimental work is that these equations are valid, each for the specific phase only, for either oil mono-

layers on water or for adsorbed films on solids. (3) The phase transformations are also the same on water and on solids: first order, gas to liquid expanded; second order, liquid expanded to intermediate, condensed to condensed, gas to intermediate; third order, intermediate to condensed. (4) The effects of temp. are, in general, the same on a solid sub-phase as on water in the low-pressure region, but the sign of the entropy term is reversed at high pressures. (5) On water, stable oil films are mono-molecular, but on solids at high vapour pressures the film becomes, in general, thick and poly-molecular without affecting the general phase relations. However, there is one exception in that on solids the higher-pressure condensed film has a higher compressibility than the lower-pressure condensed film, while on water the reverse of this is true. (6) The relations of the various phases on the surface of a solid are capable of statistical treatment.—AUTHORS.

**\*The Alterations in Scratch Hardness which Occur Through Adsorbed Fluid Films [on the Metal Surface].** Gerhard Bochmann and Liselotte Fiddecke (*Metallforschung*, 1947, 2, (7/8), 239–243).—A study was made of the variations in scratch hardness of various metals, on smearing the surface with ethyl esters of saturated fatty acids in which the number of carbon atoms varied from 2 to 12. The measurements were made with a 120° diamond under loads of 10–200 g., usually 100 g., drawn across the surface at 0.4 cm./sec. With hard metals such as antimony and cast iron the scratch hardness falls with increase in number of the carbon atoms, whereas in the case of soft metals it rises. Results for 10 g. loads give values much higher than the 100 g. load; increase of the load above this figure has little effect. The results are explained on the basis of the relative effects of cold deformation; the dispersion effect produced by the formation of adsorbed films of the lubricant preceding micro-cleavage in the case of hard metals; the formation of adsorption films in the micro-cracks in the case of soft metals with consequent internal lubrication of the glide planes of the metal; and, with low-m.p. metals, the amount of recrystallization which occurs.—E. N.

**\*An Electron-Diffraction Study of the Heating of Straight-Chain Organic Films [Deposited on Various Metals] and Its Application to Lubrication.** K. G. Brummage (*Proc. Roy. Soc.*, 1947, [A], 191, (1025), 243–252).—Electron-diffraction studies of the effect of heating films, up to 100 molecules thick, of normal paraffins, fatty acids, and esters on various metal surfaces reveal that in all cases the films lose their orderly condensed structure at comparatively low characteristic temp., leaving expanded films of individual molecules. This disorientation temp. depends on the chemical composition and thickness of the films and on the metal surface. Depending on the thick-film (20–100 molecules) disorientation temp. of fatty acids (or their soaps, as fatty acids deposited on cadmium, copper, and mild steel react to form soap films) deposited on them, the metals studied can be divided into two groups: (1) aluminium, cadmium, copper, mild steel, and stainless steel, in which the disorientation temp. are below the m.p., like the paraffins, and (2) nickel and silver, in which the disorientation temp. are above the m.p., as with esters. When the results are related to frictional data, collected from the results of other workers using the Bowden–Leben friction apparatus, on the change from smooth sliding to “stick-slip”, the measured disorientation temp. are in good agreement with the temp. of discontinuity in smooth friction, and confirm Frewing’s suggestion that the discontinuity corresponds to the change of the lubricant film structure from a condensed to an expanded state.

—E. N.

**\*Studies in Friction. I.—“Solid” versus “Polar” Boundary Films.** M. Eugene Merchant (*Phys. Rev.*, 1946, [ii], 69, (5/6), 250).—Brief abstract of a paper presented to the American Physical Society. A study was made of frictional phenomena under boundary-lubrication conditions, employing a



type of apparatus which is designed to promote pronounced "stick-slip" sliding motion, of the type used by F. P. Bowden and L. Leben (*Proc. Roy. Soc.*, 1939, [A], **169**, 371; *Met. Abs.*, 1939, **6**, 206). It was found that the effect produced by adding a non-polar but chemically "active" organic compound, such as carbon tetrachloride, to a purified mineral oil is strikingly different from that produced by adding a strongly polar compound such as oleic acid. The true kinetic friction value obtained with the pure mineral oil when applied to iron surfaces is unchanged by the addition of carbon tetrachloride, while the static friction value decreases linearly with increasing mole fraction of carbon tetrachloride. On the other hand, when oleic acid is added to the pure mineral oil, both the kinetic and the static friction coeff. drop precipitously with minor additions, then much more slowly as concentration is increased. The durability of the boundary films produced by these two types of lubricant is also very different. The behaviour referred to above may be explained by a consideration of the method of formation and nature of the surface films produced by these two different classes of materials.

—AUTHOR.

**The Effect of Grain Structure on the Electrical Conductivity of Semi-Conductors.** B. Goodman (*Phys. Rev.*, 1946, [ii], **69**, (11/12), 687).—Brief abstract of a paper presented to the American Physical Society. Only the effect due to the discontinuities introduced into the periodic lattice potential is considered, although there are probably other phenomena occurring at the grain boundaries which also hinder the flow of electrons. The boundary layers can be considered as local regions at very high "temp." with the atoms displaced up to half the interatomic distance. A simplified calculation shows that the mean free path relating to the grain-size is approx. equal to the linear dimension of the grain, as might be expected. The added resistivity may sometimes be comparable with that part of the room-temp. resistance of silicon and germanium semi-conductors due to lattice vibrations. However, it is probably always small compared to the total resistivity, which is caused mostly by the scattering from charged impurity ions. These ions result from the excitation of electrons to the otherwise empty conduction band or from the capture of electrons by acceptor impurities in the lattice.—AUTHOR.

**The Shape of Semi-Conductor Resistivity Curves.** V. A. Johnson and K. Lark-Horovitz (*Proc. Indiana Acad. Sci.*, 1946, **56**, 236).—Brief abstract of a paper presented to the Academy. If resistivity as a function of temp. is measured for a group of semi-conducting samples, the curves obtained differ in shape with the nature of the sample. As temp. rises, the resistivity continually drops for one type of sample, while for another type it rises to a maximum and then drops to a minimum, rises to a maximum, and then falls. J. and L.-H. show that the existence or non-existence of a maximum may be correlated with the Hall-effect curve of the sample. It is shown that the position of the maximum, when it exists, may also be predicted from Hall-effect data.—AUTHORS.

**Regularities in the Properties of Metallic Elements.** R. Smoluchowski (*Phys. Rev.*, 1947, [ii], **72**, (6), 538).—Brief abstract of a paper presented to the American Physical Society. A relation between metallic properties and the atomic structure of the elements is, as a rule, quite complicated because of the specific character of electronic interactions in metals, and also because of the complex nature of some of the relatively easily measured properties. Among others, Poisson's ratio—as pointed out by Köster—shows certain regularities in the periodic system. These are considered in a qualitative manner from the point of view of the repulsion between ions due to overlap and electronic forces between ions and valence electrons. The anomaly in the ferromagnetic group is discussed. Further, the differences and similarities of properties in the copper, silver, gold group are considered.—AUTHOR.

**May Lecture, 1947 : Metallurgical Problems Involved in the Generation of Useful Power from Atomic Energy.** (Sir) Wallace Akers (*J. Inst. Metals*, 1947, 73, (11), 667-680).—A brief account is given of the structure of the atom and of nuclear fission. The necessary conditions for the setting up of a fission chain reaction, and the realization of this in a slow neutron system such as a graphite-uranium pile, are described. The production of plutonium in such a pile is considered, together with its importance in the economy of processes for the generation of atomic power. The production of U.233 from thorium, and the potential importance of this, are discussed, together with the use of uranium, enriched in fissile constituent, in secondary reactors. A guess is given as to when, and under what conditions, nuclear energy may be used for power production. Finally, some figures are given on the consumption of "nuclear fuel" and the availability of supplies.—AUTHOR.

## II.—PROPERTIES OF ALLOYS

**\*A Study of Aluminium Casting Alloys Containing Copper and Silicon.** Franz Bollenrath and Hanns Gröber (*Metallforschung*, 1946, 1, (4/5), 111-116).—The aluminium corner of the aluminium-copper-silicon system was studied in the region of 4-7% of copper + silicon. Two series of alloys were prepared: (1) from pure metals, and (2) from secondary aluminium alloys. The melts were poured at 750° C. into green-sand moulds or into ingot moulds at 400° C.; solution treatment was carried out for 4 hr. at 500° C. (25° C. below the m.p. of the Al-Si-CuAl<sub>2</sub> eutectic), after which the specimens were quenched and aged for 10-50 hr. at 160° C. The pure alloys had optimum mechanical properties at the composition 2-3% copper and 4-3% silicon. The alloy with 2% copper and 4% silicon had  $\sigma_{0.2} = 6$  and 8.7,  $\sigma_B = 15$  and 18.1 kg./mm.<sup>2</sup>, and  $\delta_{10} = 5$  and 5.4%, for sand-cast and aged specimens, respectively. The warm ageing properties were dependent only on the copper content. Technical alloys with average copper and silicon contents, and containing the usual amounts of iron, manganese, and titanium and >0.5% magnesium, had better mechanical properties, except elongation, than pure alloys; thus, a sand-cast alloy with 2% copper and 4% silicon had, for cast and aged specimens, respectively,  $\sigma_{0.2} = 12.2$  and 19.6,  $\sigma_B = 16.5$  and 22.4 kg./mm.<sup>2</sup> and  $\delta_{10} = 1.8$  and 0.7%; chill castings showed tensile properties a few kg./mm.<sup>2</sup> and elongations some one-third higher than sand castings, and Brinell hardness values ~20 kg./mm.<sup>2</sup> higher. Manganese up to 0.8% and iron up to 1% had little effect on the properties of the technical alloys. Brinell-hardness values were a maximum after ageing for 10-20 hr., and the max. value (110 kg./mm.<sup>2</sup>) was shown by the alloy containing silicon 2 and copper 5%; longer ageing periods led to a reversion in properties. It is concluded that alloys of this type can be made up from secondary metals, allowing fairly wide variations in copper, silicon, manganese, and iron contents, so long as the magnesium content is between 0.2 and 0.5%.—E. N.

**\*The Alloys of Aluminium with Indium and Thallium [and Gallium].** Ernst Raub and Max Engel (*Metallforschung*, 1946, 1, (4/5), 148-149).—As the atomic number increases, the low-m.p. metals of the 3rd group of the periodic system show a decreasing affinity for aluminium. In the liquid state, gallium is miscible in all proportions, indium is only miscible up to 17.3%, and thallium is practically immiscible at all concentrations. The solubility of aluminium in indium at the monotectic temp., 634° C., is small.—E. N.

**\*Aluminium Alloys with Magnesium, Silicon, and Zinc.** Franz Bollenrath and Hanns Gröber (*Metallforschung*, 1946, 1, (4/5), 116-122).—The quaternary system Al-MgZn<sub>2</sub>-Mg<sub>2</sub>Si was studied by means of cooling curves, and in the aluminium-rich part of the diagram the course of primary crystallization



and the position of the quasi-binary eutectic Al-Mg<sub>2</sub>Si were ascertained. The ternary system is shown to have a eutectic in the same position as the Al-MgZn<sub>2</sub> eutectic, namely at 28% aluminium and 475° C. Sand castings of alloys in the aluminium corner of the system have max. tensile strengths of 10 kg./mm.<sup>2</sup>; when there is >5% MgZn<sub>2</sub> present the elongation is <0.1%, due to the large size of the MgZn<sub>2</sub> crystals. Small additions of copper, iron, and manganese have little effect on the properties. Although solution treatment at 440° C. for up to 24 hr. followed by quenching and ageing for 75–100 hr. at 100°–150° C. shows that age-hardening occurs, the effect is very slight.

—E. N.

**\*The Structure of Aluminium-Rich Alloys in the Aluminium-Silicon-Beryllium System.** Hans Nowotny (*Metallforschung*, 1946, 1, (4/5), 146–148).—A thermal and microscopic study was made of the aluminium corner of the ternary system aluminium-silicon-beryllium up to silicon 16 and beryllium 19%. There is a ternary eutectic at the composition silicon 12.3 and beryllium 6%. At 572° C. the transformation: melt = aluminium + silicon + beryllium takes place, and the doubly saturated aluminium then contains silicon 1.5 and beryllium <0.05%.—E. N.

**Aluminium Alloy Castings [—II].** (Lewis). See p. 435.

**\*Note on the Effect of Dissolved Gas on the Hot Tearing of Aluminium Casting Alloys.** (Lees). See p. 435.

**\*Effect of Iron and Silicon Impurities on the Tensile Properties and Heat-Treatment Characteristics of Sand-Cast Aluminium-10 per cent. Magnesium Alloy Test Bars.** (Parker, Cox, and Turner). See p. 435.

**Beryllium, Beryllium Alloys, and the Theoretical Principles Affecting Alloy Formation with Beryllium.** G. V. Raynor (*J. Roy. Aeronaut. Soc.*, 1946, 50, 425), 390–415).—After reviewing briefly the occurrence and production of beryllium, R. deals with the crystal structure and general physical properties of beryllium, including mechanical properties. Available information on beryllium alloys is discussed. The application of theoretical principles to beryllium and considerations connected therewith form the main feature of the paper. R. discusses the possibilities of producing ductile high-beryllium alloys and alloys strong at high temp., and makes suggestions regarding combinations that would be worthy of study.—H. S.

**\*The Development of a [Cobalt-Base] Turbo-Supercharger-Bucket Alloy.** E. Epremian (*Trans. Amer. Soc. Metals*, 1947, 39, 261–273; discussion, 273–280; and (condensed) *Canad. Metals*, 1947, 10, (1), 22–25, 31).—The effects of variations in the amounts of chromium, nickel, tungsten, molybdenum, and silicon, manganese, and carbon on the rupture strength at 650°, 815°, and 925° C. of precision-cast sample bars of a cobalt-base Vitallium-type of alloy have been studied and the results are presented graphically. The most outstanding alloy, X63, contained carbon 0.4–0.5, manganese 0.5, silicon 0.5, chromium 25, nickel 10, molybdenum 6%, and cobalt remainder. The physical and mechanical properties of X63 are detailed.—J. C. C.

**\*The Stress-Rupture and Creep Properties of Heat-Resistant Gas-Turbine Alloys.** Nicholas J. Grant (*Trans. Amer. Soc. Metals*, 1947, 39, 281–325; discussion, 325–334).—A first report of research work at the Massachusetts Institute of Technology on the development of alloys for operation at 730°–815° C. The results of stress-rupture and creep tests at 815°–980° C. are recorded for a series of Vitallium-type (cobalt-chromium-molybdenum) and nickel-chromium-cobalt iron-base alloys. All alloys were melted in a 900-g. capacity indirect-rocking-arc furnace and cast by the precision-casting technique, using a silica investment. Both alloy systems have essentially the same structures—a carbide network in an austenitic matrix. The strength of all alloys is increased to a peak value and then decreased by increasing additions of carbon. In the high-carbon ranges, with about

1% of carbon, the Vitallium-type alloys are much stronger in rupture at 815° C., slightly stronger at 870° C., slightly weaker at 925° C., and much weaker at 980° C. than the nickel-chromium-cobalt iron-base alloys, and have considerably greater (poorer) creep rates at all temp.—J. C. C.

**Precipitation-Hardened Super-Heat-Resistant Alloys [K42B and Refractaloy 72].** R. B. Gordon (*Steel Processing*, 1946, 32, (9), 561-564, 584).—The characteristics of the forgeable, precipitation-hardenable alloys K42B (nickel 42, cobalt 22, chromium 18, iron 14, titanium 2, manganese and silicon 0.7, carbon 0.05%) and Refractaloy 72 (nickel 20, cobalt 30, chromium 20, iron 15, molybdenum 8, tungsten 4, manganese 2, silicon 0.2, and carbon 0.05%) are described. K42B has been used for gas-turbine parts; but Refractaloy 72, although inferior below 1400° F. (760° C.), has the greater creep strength at higher temp. and may find applications in the future.—J. C. C.

**Gases Causing Unsoundness in Copper-Base Alloys.** L. W. Eastwood and J. G. Kura (*Foundry*, 1947, 75, (7), 70-71, 200, 202, 204, 206, 208, 210, 212, 214, 216, 218-220, 222-223).—Cf. *Met. Abs.*, this vol., p. 331. E. and K. continue their review of the literature appertaining to gas-unsoundness in copper-base alloys. The solubility of hydrogen in copper and copper-tin alloys is discussed, and theories of the mechanism of hydrogen absorption during melting are examined; the importance of deoxidation immediately before pouring is emphasized. The possibility of unsoundness being caused by carbon or its oxides is discussed; no definite conclusions on this point can be reached in the light of present knowledge. Sulphur and its oxides and nitrogen are not causes of serious unsoundness. Unsoundness is ascribed principally to hydrogen, either rejected from solution or formed by the steam reaction, and to a lesser extent to carbon monoxide, also formed by reaction during solidification. The authors discuss the effect of unsoundness on mechanical properties and point out that, under some circumstances, gas evolution during solidification may be beneficial in improving pressure-tightness and in preventing localized shrinkage. Methods of measuring the gas content of copper-base alloys are described. The various methods available for degasification are considered; these include oxidation-deoxidation methods and the use of scavenging gases. E. and K. conclude their review of literature with a brief discussion of gas absorption from the mould during the solidification period. 49 references are appended.—R. W. R.

**\*The Fatigue Characteristics of Copper-Nickel-Zinc and Phosphor-Bronze Strip in Bending Under Conditions of Unsymmetrical Loading.** G. R. Gohn and W. C. Ellis (*Amer. Soc. Test. Mat. Preprint No. 25*, 1947, 9 pp.).—Describe the results of a series of fatigue tests in bending on spring materials (copper-nickel-zinc (18% nickel silver) and phosphor bronze (8% tin)) in strip form under conditions of unsymmetrical loading. A description is given of the machine used, which subjects thin strip to complete reversals in bending stress with deflections of up to 0.300 in. at  $10^8$  cycles and 26,000 lb./in.<sup>2</sup> Previous work is discussed, and 10 references are appended.—R. L. B.

**\*Effect of Nickel on the Distribution of Lead in Leaded Plastic Bronzes.** D. P. Chatterjee (*Quarterly J. Geol. Min. Met. Soc. India*, 1946, 18, (3), 75-76).—Addition of 0.70-0.85% nickel to a 15%-lead bronze prevents the segregation of lead to a great extent. Introduction of lead in the form of granulated shot or lead wool also assists in obtaining a good distribution of lead.—AUTHOR.

**\*X-Ray Investigations of Germanium-Tin Alloys.** L. Dowell and K. Lark Horovitz (*Proc. Indiana Acad. Sci.*, 1946, 56, 237).—Brief abstract of a paper presented to the Academy. Germanium alloys with small amounts of impurities do not show any differences in crystal structure as compared with pure germanium. However, in samples containing 17% tin, definite expansion of lattice has been found. Experiments were therefore carried out in which—starting with a germanium-17% tin alloy—systematic dilutions with pure



germanium were made. These experiments show that the lattice parameter is proportional to the concentration of tin, which would indicate that the tin is going into the germanium in solid solution.—AUTHORS.

**\*Theory of Resistivity in Germanium Alloys.** K. Lark-Horovitz and V. A. Johnson (*Phys. Rev.*, 1946, [ii], **69**, (5/6), 258).—Brief abstract of a paper presented to the American Physical Society. The temp. dependence of resistivity of germanium alloys is considered in three ranges: (1) the impurity range of low temp. with conduction due to impurity electrons or holes, (2) the transition range with contributions from both impurity and intrinsic electrons and holes, and (3) the intrinsic range of temp. so high that the numbers of electrons and holes are equal. Resistivity in the impurity range is the sum of resistivity due to lattice scattering (proportional to  $T^{3/2}$ ) and resistivity due to impurity scattering. Mean-free-path calculations indicate that the impurity mean free path increases and the lattice mean free path decreases with increasing temp. At a given temp. the lattice mean free path is the same for all germanium samples, but the impurity mean free path varies widely with impurity content. In the transition and intrinsic ranges, conductivity is the sum of conductivities due to electrons and holes; their values are based on Hall-constant values. Combination of these two methods allows complete synthesis of the experimental results throughout the entire temp. range.

—AUTHORS.

**\*Electrical Properties of Germanium Alloys. I.—Electrical Conductivity and Hall Effect.** K. Lark-Horovitz, A. E. Middleton, E. P. Miller, and I. Wallerstein (*Phys. Rev.*, 1946, [ii], **69**, (5/6), 258).—Brief abstract of a paper presented to the American Physical Society. Germanium samples purified by high-vacuum treatment were alloyed by adding from 0.001 to 1.0% of metallic impurities. The electrical conductivity and transverse Hall effect of these samples were studied over temp. ranging from  $-180^{\circ}$  to  $650^{\circ}$  C. Plotting  $\log \rho$  (resistivity) and  $\log R$  (Hall constant) against  $1/T$  shows that the resistivity at low temp. decreases with increasing temp., increases around room temp., and then decreases sharply with a slope identical for the various samples. The Hall curves indicate electron (*N*-type) or hole (*P*-type) conduction, depending on the type of impurity. *P*-type samples show reversal of Hall effect, and the slope at high temp. is identical for all samples, *P* and *N* alike, indicating that germanium behaves at low temp. as an impurity semi-conductor, but is at high temp. an intrinsic semi-conductor with energy-level separation of about 0.76 V. Hall values show that the number of current carriers ranges from about  $10^{15}$  up to  $10^{19}$  per c.c. The temp. behaviour of mobility, determined by  $R/\rho$ , cannot be explained as due to lattice scattering alone, but indicates the existence of another scattering mechanism, especially at low temp.

—AUTHORS.

**\*Electrical Properties of Germanium Alloys. II.—Thermo-Electric Power.** K. Lark-Horovitz, A. E. Middleton, E. P. Miller, W. W. Scanlon, and I. Wallerstein (*Phys. Rev.*, 1946, [ii], **69**, (5/6), 259).—Brief abstract of a paper presented to the American Physical Society. The thermo-electric power  $Q$  of germanium alloys alloyed with various metallic impurities—was studied as a function of temp. from  $-180^{\circ}$  to  $650^{\circ}$  C. For this purpose, thermocouples were embedded into the body of the semi-conductors and temp. gradients of  $0.5$  to  $30^{\circ}$  C./cm. were used, depending on the temp. range and the size of the sample. The thermo-electric behaviour parallels  $R$ , the Hall effect.  $R$  and  $Q$  are positive for *P*-type samples at low temp., reversing sign at high temp. The thermo-electric power  $Q$  becomes zero at a temp. near, but not identical with, the temp. at which  $R$  becomes zero. In most cases  $Q$  as a function of temp. rises in the low temp. range, passes through a maximum and decreases almost near room temp. The position and height of the maximum depends on the amount and type of impurity used. The temp. dependency of  $Q$  for

samples containing the same type of impurity in varying amounts is represented by a family of similar curves: with increasing impurity the position of the maximum shifts to higher temp. and lower values.—AUTHORS.

**Tentative [A.S.T.M.] Specifications for Corrosion-Resistant Iron-Chromium and Iron-Chromium-Nickel Alloy Castings for General Applications (A296-46T).** — (*Book of A.S.T.M. Standards, 1946, (IA), 1011-1015*).

**Tentative [A.S.T.M.] Specifications for Heat-Resistant Iron-Chromium and Iron-Chromium-Nickel Alloy Castings for General Applications (A297-46T).** — (*Book of A.S.T.M. Standards, 1946, (IA), 1016-1019*).

**Standard [A.S.T.M.] Specifications for Ferro-Chromium (A101-42).** — (*Book of A.S.T.M. Standards, 1946, (IA), 637-638*).

**Standard [A.S.T.M.] Specifications for Ferro-Manganese (A99-39).** — (*Book of A.S.T.M. Standards, 1946, (IA), 633-634*).

**Standard [A.S.T.M.] Specifications for Ferro-Molybdenum (A132-39).** — (*Book of A.S.T.M. Standards, 1946, (IA), 641-642*).

**Standard [A.S.T.M.] Specifications for Ferro-Silicon (A100-39).** — (*Book of A.S.T.M. Standards, 1946, (IA), 635-636*).

**Standard [A.S.T.M.] Specifications for Ferro-Tungsten (A144-39).** — (*Book of A.S.T.M. Standards, 1946, (IA), 643-644*).

**Standard [A.S.T.M.] Specifications for Ferro-Vanadium (A102-39).** — (*Book of A.S.T.M. Standards, 1946, (IA), 639-640*).

**\*A Study of the Magnesium-Cadmium Alloys in the Region of the Compound  $Mg_3Cd$ .** N. Ageew and D. Ageewa (*Acta Physicochim. U.R.S.S.*, 1946, 21, (4), 749-763).—[In English]. See *Met. Abs.*, 1947, 14, 46.—S. G.

**\*The Structure of Magnesium-Rich Alloys in the Magnesium-Manganese-Mercury System.** Hans Nowotny (*Metallforschung*, 1946, 1, (4/5), 130-136).—The ternary system magnesium-manganese-mercury was studied up to manganese 12 and mercury 18%, using thermal and X-ray methods. In the magnesium-manganese melts, magnesium is in equilibrium with  $\alpha$  manganese at low temp. and with  $\beta$  manganese at high temp.; a sample quenched from 800° C. shows  $\beta$  manganese which, after annealing for 2 hr. at 550° C., is transformed into  $\alpha$  manganese. The existence of the compound  $Mg_3Mn$  was not confirmed, while at the peritectic temp. the max. solubility of manganese in magnesium is ~3% lower than that previously given. The intense segregation of manganese in alloys containing >3% manganese is somewhat lessened by additions of mercury. In magnesium-mercury alloys, at the eutectic temp., 448° C., magnesium is saturated with ~3% mercury; the mercury-rich phase consists of  $Mg_3Hg$ . The three-phase ternary alloys consist of an equilibrium between Mg, Mn, and  $Mg_3Hg$ , while at the peritectic (452° C.) the four-phase equilibrium  $S + \alpha Mn = Mg + Mg_3Hg$  occurs, the doubly saturated magnesium solid solution containing 0.3% manganese and 1.8% mercury. At 400° C. the magnesium solid solution has lattice constants of  $a = 3.1995$  and  $c/a = 1.6249$  and is in equilibrium with  $\alpha Mn$  and  $Mg_3Hg$ . As the manganese and mercury contents rise, the Brinell hardness rises accordingly, e.g. manganese 1 and mercury 0%, 40 kg./mm.<sup>2</sup>; manganese 9 and mercury 0%, 52 kg./mm.<sup>2</sup>; manganese 1 and mercury 11%, 52 kg./mm.<sup>2</sup>; manganese 9 and mercury 11%, 65 kg./mm.<sup>2</sup>. The ternary alloys with >3% mercury are rapidly attacked by water. Due to the low m.p. eutectic,  $Mg + Mg_3Hg$ , additions of >0.5% mercury are unsuitable; specimens containing manganese 1.5-2 and mercury 0.4% show no oxide formation on annealing at 520° C. The ternary alloys show no cold-aging.—E. N.

**\*A Method to Measure Complex Permeabilities of Metals at U.H.F. [and Its Application to Magnetic Iron and Mo-Permalloy].** M. H. Johnson, G. T. Rado, and M. Maloof (*Phys. Rev.*, 1947, [ii], 71, (7), 472).—Brief abstract of a paper



presented to the American Physical Society. Complex permeabilities in the surface layer of ferromagnetics with known D.C. resistivity can be computed from the attenuation and phase velocity in a co-axial line whose centre conductor is ferromagnetic. These quantities can be found experimentally by measuring simultaneously the change in  $Q$  and in the resonant frequency ( $\sim 0.01\%$ ) when a metal is substituted for the ferromagnetic portion of the centre conductor in a co-axial resonator. A mechanical substitution invariably produces a greater change in resonant frequency by alteration of geometrical conditions than by removal of the ferromagnetism. The difficulty can be circumvented with the use of a polarizing field which is parallel to the small radio-frequency field and is strong enough completely to saturate the ferromagnetic material. It is thus possible to compare resonant frequencies (and  $Q$ 's) for the actual permeability and for unit permeability without altering the geometrical conditions. High-power dissipation and the transient skin effect of the current producing the polarizing field in the centre conductor require, respectively, pulse technique and milli-second periods. Application of the method at 200 Mc./s. to magnetic iron and Mo-Permalloy shows that their permeabilities ( $\sim 100$ ) are much smaller than the D.C. values and have a large out-of-phase component.—AUTHORS.

**\*Complex Permeability of Permalloy.** M. H. Johnson, G. T. Rado, and M. Maloof (*Phys. Rev.*, 1947, [ii], 72, (2), 173).—Brief abstract of a paper presented to the American Physical Society. The authors' method for measuring complex permeability (*Phys. Rev.*, 1947, [ii], 71, 472; see preceding abstract) was applied to 45-Permalloy and Mo-Permalloy. Preliminary results indicate that the behaviour of these high- $\mu$  substances is similar to that of magnetic iron (Johnson, Rado, and Maloof, *Phys. Rev.*, 1947, [ii], 71, 322; and Rado, Johnson, and Maloof, *ibid.*, p. 472) in that the 200-Mc./s. permeability is small and is nearly const. for polarizing fields below the knee of the magnetization curve. Correlation of the results with D.C. measurements and their interpretation in terms of the mechanism of magnetization are discussed.—AUTHORS.

**\*Preparation of a Raney Nickel Catalyst.** A. A. Pavlic and Homer Adkins (*J. Amer. Chem. Soc.*, 1946, 68, (8), 1471).—Describes a procedure for preparing Raney nickel from the nickel-aluminium alloy. The catalyst so obtained is more active, particularly at temp. below  $100^\circ\text{C}$ ., than is Raney nickel prepared by other procedures known to P. and A.—AUTHORS.

**\*Magnetic Domain Patterns on Silicon-Iron Crystals.** H. J. Williams (*Phys. Rev.*, 1946, [ii], 70, (1/2), 106).—Brief abstract of a paper presented to the American Physical Society. Magnetic-powder patterns of several new types were observed in carefully purified single crystals of iron-silicon alloys containing 3.8% silicon. Surfaces were parallel to (100), (110), and (211) planes. When a (100) surface was carefully polished mechanically in the usual way, "maze" patterns were found, like those reported by Kaya (*Z. Physik*, 1934, 89, 796) and by McKeehan and Elmore (*Phys. Rev.*, 1934, [ii], 46, 226; *Met. Abs.*, 1934, 1, 496). When electrolytically polished as suggested by Elmore (*Phys. Rev.*, 1937, [ii], 51, 982; *Met. Abs.*, 1937, 4, 339), the same surface showed lines running along [110] directions and then curving together in pairs to form points (like dagger blades). Near saturation this pattern disappeared and the usual series of lines formed perpendicular to the applied field, as observed by Bitter (*Phys. Rev.*, 1934, [ii], 41, 507). On (110) surfaces magnetized in a [110] direction, intricate figures appeared in rows about 0.1 mm. apart. As the magnetization increased, these figures grew in size and changed again to the usual series of line segments perpendicular to the field. Still other patterns were observed on the (211) surfaces. Fields were applied either parallel or perpendicular to the surface examined. The colloid used was magnetite, supplied by Elmore.—AUTHOR.

**\*Diffusion Behaviour of Noble-Metal Plates. II.**—[Silver-Aluminium, Silver-Zinc, and Silver-Cadmium]. Helmut Bückle (*Metallforschung*, 1946, 1, (6), 175-181).—Cf. *Met. Abs.*, this vol., p. 261. The diffusion curve obtained when two metal plates are heated together is shown to be a parabola,  $d = a\sqrt{t}$ , where  $d$  is the depth of penetration in  $\mu$  and  $t$  is the time of heating in hr. After 100 hr. the hourly increment of  $d$ ,  $\Delta d$ , approximates to the tangent to the curve at the point  $d_{100}$ , such that  $\Delta d = \frac{a}{20}$ . Values of  $a$ ,  $d_{100}$ , and  $\Delta d$ , for the penetration of silver at different temp. are given for the metal pairs silver-aluminium, silver-zinc, and silver-cadmium. For silver-aluminium,  $\Delta d = 0.2, 0.52$ , and  $1.82 \mu$  at  $300^\circ, 400^\circ$ , and  $500^\circ \text{C.}$ , respectively. For silver-zinc,  $\Delta d = 0.36, 1.75$ , and  $3.78 \mu$  at  $200^\circ, 300^\circ$ , and  $400^\circ \text{C.}$ , respectively; with this pair an intermediate layer is formed due to an anomalous diffusion equilibrium at the interface. For silver-cadmium at  $300^\circ \text{C.}$   $\Delta d$  has a value between that of silver-aluminium and silver-zinc; difficulties were encountered with this pair as it was hard to obtain complete adherence between the two metals.—E. N.

**\*An X-Ray-Diffraction Study of the Silver-Magnesium Alloy System.** Harold R. Letner and S. S. Sidhu (*J. Appl. Physics*, 1947, 18, (9), 833-837).—Four homogeneous solid solutions were found in the system silver-magnesium. The  $\alpha$  primary solid solution of magnesium in silver has a face-centred cubic structure, and the  $\beta$  solid solution has a body-centred cubic structure. The  $\gamma$  solid solution appears to have a complicated structure; while others have identified it as hexagonal, no definite structure could be assigned to it from the present authors' diffraction data. The  $\delta$  solid solution has the hexagonal close-packed structure of magnesium. The lattice parameter  $a_0$  in the  $\alpha$  solid solution increases with increasing magnesium concentration, but shows a marked negative deviation from Vegard's law. The  $a_0$  in the  $\beta$  solid solution, however, increases linearly with increasing magnesium concentration. Silver and magnesium atoms are distributed at random in the  $\alpha$  phase, but take up preferred positions in the  $\beta$  phase. The ordering process takes place throughout the  $\beta$  phase, but is most nearly complete in the region of 50 at.-% magnesium.—AUTHORS.

**On the Calculation of the Velocity of Eutectic Crystallization, with Special Reference to Pearlite.** Erich Scheil (*Metallforschung*, 1946, 1, (4/5), 123-130).—Mathematical.—E. N.

### III.—STRUCTURE

#### (Metallography ; Macrography ; Crystal Structure.)

[For all abstracts on the constitution of alloy systems, including X-ray studies, see II.—Properties of Alloys.]

**\*High-Temperature Anelastic Effects in Polycrystalline Aluminium.** T'ing-Sui Kê (*Phys. Rev.*, 1946, [ii], 70, (1/2), 105).—Brief abstract of a paper presented to the American Physical Society. The sudden drop of temp. coeff. of elastic modulus ( $dG/dT$ ) of certain metals at high temp. has often been reported, and vaguely attributed to a sudden change in strength. The rigidity of fine-grained 99.991% aluminium wires was determined, using a dynamic torsional method, from room temp. to  $450^\circ \text{C.}$  The wire was first annealed at  $450^\circ \text{C.}$  for 5 hr., to eliminate effects of cold work and to give a stable grain-size. A sudden drop in  $dG/dT$  was observed around  $200^\circ \text{C.}$  This drop was not observed in single-crystal aluminium wires. The behaviour of polycrystalline aluminium can be interpreted as due to viscous slip along grain boundaries. The grain boundaries apparently behave in a viscous manner with the velocity decreasing with temp., as first suggested by Rosenhain in



1912. The temp. at which the elastic-modulus curve changes slope corresponds to the temp. at which the relaxation time associated with the slip is comparable to the period of torsional vibration. This picture is supported by measurements of internal friction and elastic after-effects, which are related phenomena resulting from anelasticity, a property by virtue of which strain lags behind stress in the conventionally elastic range (C. Zener and J. H. Hollomon, *J. Appl. Physics*, 1946, **17**, 69; *Met. Abs.*, 1946, **13**, 242).—AUTHOR.

**\*Boltzmann's Superposition Principle and the Viscous Behaviour of Grain Boundaries in Metals [Aluminium and Magnesium].** T'ing-Sui Kê (*Phys. Rev.*, 1947, [ii], **71**, (2), 142).—Cf. preceding abstract. Brief abstract of a paper presented to the American Physical Society. The mechanical behaviour of grain boundaries in metals has been a subject of continual controversy. The present research was designed to examine thoroughly the mechanical behaviour of grain boundaries in metals in a quantitative manner. A simple torsional apparatus was devised for measuring 4 types of anelastic effects at very low stress levels, namely internal friction at low frequencies, variation of dynamic rigidity with temp., creep under const. stress, and relaxation at const. strain. All 4 types of anelastic effects were studied in 99.991% polycrystalline aluminium, as well as in single-crystal aluminium; the behaviour in the two cases is very different. The 4 types of anelastic effects observed in polycrystalline aluminium satisfy the inter-relations derived by Zener from Boltzmann's superposition principle within the experimental error. These measurements corroborate quantitatively the concept that the grain boundaries behave as if they were viscous, with a coeff. of viscosity decreasing with increasing temp. The heat of activation associated with the viscous slip along the grain boundaries was found to be 34,500 cal./mole, corresponding to a rapidly decreasing grain-boundary viscosity with increasing temp. Similar anelastic effects were also observed in polycrystalline magnesium, indicating that the viscous behaviour of grain boundaries is probably common to all metals.—AUTHOR.

**\*Effect of Grain-Size and Frequency of Measurement Upon Internal Friction and Rigidity Modulus of Aluminium.** T'ing-Sui Kê (*Phys. Rev.*, 1947, [ii], **72**, (2), 174).—Cf. preceding abstract. Brief abstract of a paper presented to the American Physical Society. The temp. dependence of internal friction and rigidity modulus of 99.991% aluminium were measured as a function of grain-size of the specimen and as a function of frequency of measurement. It was found that when the frequency of measurement is kept const., an increase of grain-size shifts the internal-friction curve and the rigidity-relaxation curve (both *versus* temp.) to higher temp., and a decrease in grain-size causes a shift to lower temp. So long as the grain-size is smaller than the linear dimensions of the specimen, the max. internal friction and the relaxation strength ( $G_R - G_T$ ) are independent of grain-size. It was also found that when the grain-size of the specimen is kept the same, a change in frequency of measurement has exactly the same effect as a change of grain-size. It is shown that these observed phenomena are necessary manifestations of the viscous behaviour of the grain boundaries in metals, which behaviour has been demonstrated by previous measurements on anelastic effects (T.-S. Kê, *Phys. Rev.*, 1946, [ii], **70**, 105; 1947, [ii], **71**, 142 (see abstracts above); and a forthcoming paper). The heat of activation associated with the grain-boundary slip, as determined by the internal-friction and by rigidity measurements, is in both cases 32,000 cal./mole, which agrees, within experimental error, with the previously reported value obtained by creep and stress-relaxation measurements.—AUTHOR.

**\*High-Power Microscopical Investigation for an Explanation of the Precipitation Processes in Beryllium Bronze.** Johanna Hunger, Franz Pawlek, and Robert Seeliger (*Metallforschung*, 1946, **1**, (6), 168–174).—A study was made of

the age-hardening of a copper-alloy containing 2.83% beryllium by high-power microscope, electron-microscope, and Brinell-hardness observations. The specimens were annealed for 5 hr. at 800° C. in an atmosphere of pure hydrogen, quenched in water, and aged for 7 min.—8 hr. at temp. between 250° and 550° C. Precipitation of the  $\gamma$  phase in the  $\alpha$  crystals occurs as a stage in the hardening process, but its rate is only slightly increased by raising the time and temp. of ageing. Although the light microscope only reveals the eutectoid decomposition  $\beta = \alpha + \gamma$  at 550° C., the electron microscope clearly shows that it begins at 450° C. Micro-hardness determinations show that, as compared with the  $\alpha$  phase, the max. hardness of the  $\beta$  constituent is attained after shorter periods of time or at lower temp. As the very hard  $\beta$  constituent exerts no perceptible influence on the total hardness, the macro-hardness is determined only by the micro-hardness of the  $\alpha$  ground-mass.

—E. N.

**\*A Study of Gold Smokes with the Electron Microscope.** Louis Harris and Benjamin M. Siegel (*J. Appl. Physics*, 1948, 19, (1), 123).—Brief abstract of a paper presented to the Electron Microscope Society of America. The particle size and the distribution in deposits of various gold smokes were studied at high resolution with the electron microscope. The smokes were produced by evaporating gold from a hot tungsten filament in a partial atmosphere of nitrogen, and were deposited on thin collodion films. It was found that both the size of the unit colloidal gold particles and the manner of their aggregation varied markedly with the pressure of the atmosphere and the rate of evaporation. The optical properties of the deposits were also found to depend on these factors. Measurements in the visible and infra-red regions of the spectrum have been correlated with the electron-microscope observations.

—AUTHORS.

**\*An Oxide Replica Technique for the Electron-Microscope Examination of Stainless Steel and High-Nickel Alloys.** E. M. Mahla and N. A. Nielsen (*J. Appl. Physics*, 1948, 19, (1), 126).—Brief abstract of a paper presented to the Electron Microscope Society of America. An oxide replica method has been developed which is suitable for the electron-microscope examination of the surfaces of stainless steel, nickel, and high-nickel alloys. The oxide film is produced on the metal surface by oxidation in a molten nitrate solution and is chemically stripped from the base metal by a bromine-methanol solution. Replicas of this type have been used to study deep-etched structures, preferential etch attack, and secondary phases in austenitic and ferritic stainless steel, and nickel.—AUTHORS.

**\*Knowledge on the Structure and Crystal Chemistry of Some Noble-Metal Systems (Palladium-Lead, Palladium-Tin, Iridium-Tin, Rhodium-Tin, and Platinum-Lead).** Hans Nowotny, Konrad Schubert, and Ursula Dettinger (*Metallforschung*, 1946, 1, (4/5), 137-145).—An X-ray and micrographic examination of the alloys was made with the following results: **Palladium-Lead.** (1) The  $\alpha$  solid solution exists up to ~24% lead (at 1200° C.) and has a cubic structure with  $a_w = 3.952$  Å. (2)  $\text{Pd}_3\text{Pb}$  has a cubic face-centred crystal of the  $\text{Cu}_3\text{Au}$  ( $L1_2$ ) type with  $a_w = 4.0135$  Å. (3)  $\text{Pd}_3\text{Pb}_2$  is formed peritectically from the  $\text{Pd}_3\text{Pb}$  melt at 830° C.; it has a partly filled  $\text{NiAs}$  structure; for  $\text{Pd}_{3.1}\text{Pb}_2$ ,  $a = 4.4650$ ,  $c = 5.7090$  Å, and  $c/a = 1.2785$ . (4)  $\text{PdPb}$  has a monoclinic elementary cell, similar to  $\text{Ni}_3\text{Sn}_4$ , with  $a = 7.08$ ,  $b = 8.425$ ,  $c = 5.56$  Å, and  $\cos \beta = 0.3256$ . (5)  $\text{Pd}_2\text{Pb}$  was not found. **Palladium-Tin.** (1) The existence of the  $\text{Pd}_3\text{Sn}_2$ -Sn eutectic at 0.18% palladium and 0.6° C. below the m.p. of the tin was not confirmed. (2) The palladium-tin solid solution exists up to ~25 at.-% tin; it has a cubic face-centred lattice with  $a_w = 3.875$ -3.970 Å. (3)  $\text{Pd}_2\text{Sn}$  exists, but the structure was not identified. (4)  $\text{Pd}_3\text{Sn}_2$  has a hexagonal, partly filled  $\text{NiAs}$ -type structure with, at 40.6% tin,  $a = 4.389$ ,  $c = 5.703$  Å, and  $c/a = 1.298$ .



(5) PdSn has an orthorhombic  $B31$ -type cell having  $a = 3.86$ ,  $b = 6.12$ ,  $c = 6.31$  Å, and a density of  $9.4$  g./cm.<sup>3</sup> (6) PdSn<sub>2</sub> has a large pseudo-cubic or at least pseudo-tetragonal structure; it is definitely not a  $C1$  or  $C16$  type. (7) PdSn<sub>4</sub> has an unidentified structure. (8) Pd<sub>3</sub>Sn exists probably at low temp. through ordering of the palladium-tin solid solution. *Rhodium-Tin.* (1) Rh<sub>3</sub>Sn<sub>2</sub> has a partly filled NiAs ( $B8$ ) structure which, between 41 and 44% tin, has  $a = 4.331$ ,  $c = 5.542$  Å, and  $c/a = 1.2794$ . *Iridium-Tin.* (1) The  $\alpha$  solid solution has a cubic structure with  $a_w = 3.87$  Å. (2) IrSn has a NiAs-type structure, the existence of an  $L1_2$  type being very improbable; it has  $a = 3.980 \pm 0.001$ ,  $c = 5.556 \pm 0.001$  Å, and  $c/a = 1.396$ , and a density of  $13.1$  g./cm.<sup>3</sup> *Platinum-Lead.* (1) Pt<sub>3</sub>Pb, which is the platinum-rich phase, has a cubic close packing with  $a_w = 4.045$  Å against  $a_w = 4.17$  calculated from Vegard's rule. An  $L1_2$  type also exists. (2) PtPb has a filled NiAs structure with  $a = 4.250$ ,  $c = 5.456$  Å, and  $c/a = 1.2837$ . (3) The lead-rich intermetallic phase has a composition near to PtPb<sub>4</sub>; it does not possess a simple lattice.—E. N.

**\*On the Crystal Structure of Sintered Hard Metals, Particularly Tungsten Carbide-Titanium Carbide-Cobalt Alloys.** Richard Kieffer (*Metallforschung*, 1947, 2, (7/8), 236–238).—The crystal structure of sintered hard-metal compacts formed of carbides with cobalt can be accentuated by sintering at  $1500^\circ$  C. for 120 hr., when a coarse crystal structure is produced in the carbide phase which can be developed by the following etching process. The specimen is treated with a mixture of hydrofluoric and nitric acids, then an alkaline solution of potassium ferricyanide, followed by 30 min. in a mixture of phosphoric acid and hydrogen peroxide, which attacks the  $\beta$  phase and the cobalt matrix but does not attack the  $\alpha$  phase; at this stage the white, angular  $\alpha$  solid-solution crystals can just be differentiated from the yellow, rounded  $\beta$  solid-solution crystals and the white cobalt matrix. The solid-solution phases are finally resolved by giving the specimen a quick immersion in dilute ammonium sulphide, which leaves them unattacked but turns the cobalt matrix a dark colour. Using this technique, compacts of tungsten carbide with up to 13% cobalt are shown to consist of a carbide phase consisting of regular, almost trigonal prisms in a binding phase or matrix of cobalt. A compact of tungsten carbide 86, titanium carbide 5, and cobalt 9% shows practically the same structure, although here the homogeneous phase consists of a solution of titanium carbide in tungsten carbide. A compact of tungsten carbide 25, titanium carbide 67, and cobalt 8% also shows two phases, but here the carbide phase consists of a solid solution of tungsten carbide in titanium carbide, the crystals being small and cubic with well rounded corners and edges. The results confirm X-ray measurements that up to 5% titanium carbide is soluble in tungsten carbide, forming the  $\alpha$  phase, and that up to 70% tungsten carbide is soluble in titanium carbide, forming the  $\beta$  phase. The method can be applied to the analysis of the structures of most hard-metal compacts formed from sintered carbides.—E. N.

**Changing the Stressed State at the Surface of Metals by Etching.** F. Lihl (*Arch. Metallkunde*, 1946, 1, (1), 16–25).—Steels subjected to chemical or electrolytic attack are found to possess surface stresses—"etch stresses". They are always compressive, are independent of the acid used, and can be removed by subsequent heat-treatment. The only time they do not appear is on electrolytic polishing in slightly acidified water. Their magnitude depends upon the material, its heat-treatment, and, in electrolytic polishing, the c.d. An explanation is advanced, based on the fact that the adsorption of gases by metals, which enlarges the lattice parameters, causes surface stresses to operate in the same direction. Thus, the true effect of the gas adsorption on the lattice parameters is less than that measured and, for example, in the case of iron is only about half as large as measurements indicate.—E. N.

**\*X-Ray Micro-Radiographic Study of Strains in Crystals.** C. M. Lucht, M. Mann, and R. Smoluchowski (*Phys. Rev.*, 1946, [ii], **69**, (5/6), 256).—Brief abstract of a paper presented to the American Physical Society. Cf. *Met. Abs.*, 1947, **14**, 100. In a previous X-ray micro-radiographic study of compounds and diffraction effects in various metals and alloys (J. M. Hurd, C. M. Lucht, and R. Smoluchowski (*Phys. Rev.*, 1945, [ii], **68**, 100), a selective transition within single grains was observed. Certain grains appear to have a "mottled" pattern which depends on the orientation of the grain. This phenomenon was further studied and interpreted as due to a diffraction effect in imperfect grains. By using filtered radiation and improving the experimental technique, many additional features were brought out which confirm this interpretation and provide a tool for the study of strains within single grains. This method permits a study of strain distribution and temp. influence during annealing and cold working. Strain discontinuities at twin and grain boundaries can be observed.—AUTHORS.

**\*Dynamic Theory of the Vibration Spectra of Crystals. IV.—Metallic Crystals.** K. G. Ramanathan (*Proc. Indian Acad. Sci.*, 1947, [A], **26**, (6), 507–510).—Exact expressions are derived for the frequencies of eigen-vibrations of the face-centred and body-centred cubic lattices in terms of 6 and 5 force constants, respectively, the constants in each case being connected by one additional relation.—AUTHOR.

**The Effect of Grain Structure on the Electrical Conductivity of Semi-Conductors.** (Goodman). See p. 395.

## V.—POWDER METALLURGY

**Standard [A.S.T.M.] Specifications for Aluminium Powder for Paints—Aluminium-Bronze Powder (D266-41).** — (*Book of A.S.T.M. Standards*, 1946, (II), 912–913).

**Standard [A.S.T.M.] Methods of Sampling and Testing Aluminium Powder and Paste (D480-44).** — (*Book of A.S.T.M. Standards*, 1946, (II), 923–927).

**Standard [A.S.T.M.] Specifications for Gold Bronze Powder (D267-41).** — (*Book of A.S.T.M. Standards*, 1946, (II), 916–917).

**\*On the Crystal Structure of Sintered Hard Metals, Particularly Tungsten Carbide-Titanium Carbide-Cobalt Alloys.** (Kieffer). See p. 405.

**Standard [A.S.T.M.] Specifications for Zinc Dust (Metallic Zinc Powder) (D520-41).** — (*Book of A.S.T.M. Standards*, 1946, (II), 918).

**Tentative [A.S.T.M.] Method of Test for Particle-Size Distribution of Sub-Sieve-Size Particulate Substances (E20-33T).** — (*Book of A.S.T.M. Standards*, 1946, (III<sub>A</sub>), 1219–1223).

## VI.—CORROSION AND RELATED PHENOMENA

**\*Resistance of Aluminium to Corrosion in Solutions Containing Various Anions and Cations.** A. B. McKee and R. H. Brown (*Corrosion*, 1947, **3**, (12), 595–612).—A comprehensive series of tests was carried out to determine the corrosive effects of various ions and combinations of ions, on aluminium. The test specimens were of degreased and dried foil of commercial purity and they were exposed in beakers under quiescent conditions at room temp. losses in weight being determined. The ions studied were sodium, ammonium sulphate, phosphate, nitrate, chloride, carbonate, acetate, and chromate. It was concluded that aluminium resisted corrosion by acetic acid, irrespective of the presence or absence of ammonium or sodium, by mineral acids up to



0.001N, by phosphoric acid up to 0.01N, or 0.2N if sodium or ammonium salts were present, by ammonia, by sodium hydroxide below 0.1N if the chromate ion was present to a concentration of 1.0N, and by sodium carbonate up to 0.001N. It was corroded by sodium hydroxide over 0.0005N in the presence or absence of any of the anions except chromate. In the presence of single anions corrosion increased in the order: acetate, phosphate, sulphate, nitrate, and chloride. Sodium chloride, nitrate, sulphate, and acetate did not affect corrosion by sodium hydroxide, but sodium chromate retarded it. Sodium carbonate above 0.001N behaved similarly to the hydroxide. The corrosion-resistance generally appeared to depend on the stability of the oxide film and the solubility of the corrosion products.

—M. A. V.

**Aluminium Used in Combating Tank Corrosion.** Gordon W. Alexander (*Petroleum Refiner*, 1947, 26, (12), 99).—A brief note on the use of aluminium for storage-tank roofs in the petroleum industry in order to combat corrosion by hydrogen sulphide and free sulphur. The tanks in question were run-down tanks for the gasoline cut from the thermal cracking unit. Steel roofs suffered serious corrosion in this application. 4-in. steel channel sections were used as rafters, but placed on the top side of the aluminium sheet. The roof sheets were fabricated in 90° segments and then fitted to the tank. Aluminium rivets were used, and lead was employed as a gasket material to make the joints vapour-tight.—G. T. C.

**\*A Zinc-Base Alloy of High Aluminium Content. III.—Water-Vapour Corrosion of Forging Alloys.** Erich Gebhardt (*Metallforschung*, 1947, 2, (7/8), 225–230).—A study was made of the water-vapour corrosion, at 95° C., of a zinc-base alloy containing aluminium 32 and copper 3%, in the form of forged rods. Alloys made from technically pure metals had corrosion films ~0.05 mm. thick after 5 days' testing. Additions of lead, cadmium, or zinc increased the susceptibility to corrosion, but the deleterious effects of these metals could be lessened by addition of magnesium; iron, silicon, manganese, or nickel had no deleterious effects on the corrosion properties. Commercial alloys, prepared from secondary metals, showed much greater rates of corrosion; after 5 days the corrosion films were 0.35–0.5 mm. thick. Of all metals, the presence of lead had the worst effect on the corrosion-resisting properties.—E. N.

**\*Contribution to the Question of Water-Vapour Corrosion of Zinc Alloys Containing Aluminium. IV.—On the Influence of Lead [and Magnesium].** Karl Löhberg (*Metallforschung*, 1947, 2, (7/8), 230–232).—Cf. preceding abstract. The distribution of lead in a eutectic alloy containing zinc 95 and aluminium 5% was examined by additions of lead and its radio-active isotope, thorium B, and the effect of the lead and of addition of 0.2% magnesium on the corrosion-resistance was studied. After 18 hr. at 95° C. in a moist atmosphere, corrosion had commenced; the alloy containing 0.7% lead was completely disintegrated after 2 days, while the alloy containing 0.4% lead took 3–4 days to reach a similar state. The lead is concentrated as large globules at the grain boundaries of the eutectic crystals, and it is in these places that corrosion begins. On addition of magnesium the lead is probably converted to  $Mg_2Pb$  and, although still intercrystalline, is more finely dispersed and evenly distributed. The corrosion-resistance of the magnesium-containing alloys is greater than that of the magnesium-free alloys, but this is partly due to the reduction in crystal size brought about by magnesium.—E. N.

**\*Investigation of Cavitation in Aluminium and Zinc Alloys.** Hans Nowotny (*Metallforschung*, 1946, 1, (6), 182–192).—After a general review of the destruction of metals by cavitation and its likeness to oxide attack on heating, the effect of surface condition, and the extent to which chemical corrosion is

involved, a systematic study is made of the cavitation of aluminium and zinc alloys with reference to: (1) surface condition, (2) the influence of individual structures, and (3) the relationship between zone of destruction and pressure. The presence of pores and pipes increases the rate of attack, and dense, pressed structures behave better under small pressures than cast alloys. In hyper-eutectic aluminium-silicon alloys, the hard, primary precipitated silicon crystallites are practically unattacked as compared with the softer eutectic; hard  $\text{Al}_3\text{Ti}$  behaves in a similar manner, while softer phases are badly disintegrated even at small vibrational amplitudes. In aluminium-magnesium and aluminium-copper-nickel alloys, the soft primary precipitated aluminium solid-solution crystals are similarly crumbled and the surface destroyed, as are the pure aluminium crystallites. Fuels such as benzene and benzole have less effect than water, and even hot benzene has little effect on alloys with low resistance to water cavitation. If the rate of attack of water at  $20^\circ\text{C}$ . on aluminium and zinc alloys is taken as unity, then the values for methyl alcohol (at  $20^\circ\text{C}$ .) and ethyl alcohol (at  $30^\circ\text{C}$ .) are 0.08 and 0.15, respectively.—E. N.

**\*Selecting Alloys to Resist Cavitation Erosion.** R. Beeching (*Product Eng.*, 1948, 19, (1), 110-113).—Three testing methods were used: (1) a rapidly rotating wheel carrying the specimen through a liquid jet; (2) the obstacle placed in the throat of a Venturi tube, causing a cavitation zone over the test plate; and (3) a special vibratory test apparatus. The alloys tested by vibratory methods were: brass, aluminium bronze, cast Monel metal, gun-metal, copper-nickel-zinc alloy, cast iron, cast stainless steel, and cast light alloy. A table shows the weight lost by the various cast alloys during 60 min. erosion in sea water or distilled water (vibratory test). The choice of alloy is then discussed according to the requirements of specified parts.—H. V.

**\*A Note on the Reactions Between Water Vapour and Hydrogen Peroxide and Light Metals at Elevated Temperatures.** Oswald Kubaschewski and Hans Ebert (*Metallforschung*, 1947, 2, (7/8), 232-235).—The differing rates of reaction of magnesium and aluminium with water vapour and hydrogen peroxide at  $400^\circ\text{C}$ . are due to the differing vol. quotients,  $V_{\text{oxide}}/V_{\text{metal}}$ . For magnesium the ratio is 0.81 and for aluminium 1.50, so that, whereas for magnesium the deciding factor in the reaction velocity is the amount of water vapour present, in the case of aluminium it is the rate of diffusion of aluminium through the aluminium oxide film. Magnesium-aluminium alloys behave as if both metals are present in the unalloyed condition.—E. N.

**\*On the Influence of Stress on the Risk of Failure by Stress-Corrosion [of Aluminium Alloys].** Kurt Matthaes (*Metallforschung*, 1947, 2, (7/8), 213-225).—High-strength light-metal alloys such as aluminium-copper-magnesium and aluminium-zinc-magnesium are used in spite of their known sensitiveness to stress-corrosion and the fact that specimens generally give deformation values higher than those possible in practice. Tests show that: (1) in general there is no lower limit below which a material is absolutely resistant to stress-corrosion, although in practice the life at lower stresses is so high that a good degree of safety can be reached under usual corrosion conditions, and notches do not increase the tendency to failure; and (2) stress-corrosion cannot be considered only as an electrochemical solution process, for the magnitude of the stress is just as important as other influences, such as the nature of the corrosive medium and the condition of the material (cold worked, annealed, &c.), and similar cracks and breaking appear in synthetic resins, where no electrochemical solution is possible. Thus, stress-corrosion failure is a genuine failure similar to that by fatigue or corrosion fatigue. Further tests on stress-corrosion failure by other than



tensile stress—by torsional or alternating-bend tests—show that failure always occurs as a normal tensile failure in which the rupture planes are always perpendicular to the max. tensile stress. It is concluded that the risk of failure cannot be explained simply by the normal stress hypothesis or any other similar theories such as those of max. extension, energy of change of state, or shear stress, as it depends largely on the degree of plastic deformation. Failure under stress near to the elastic or proof stress can be largely explained by the energy of change of state hypothesis; at higher stresses the shear stress hypothesis is more appropriate.—E. N.

**\*The Cause of Stress-Corrosion Sensitiveness in Homogeneous Alloys.** Ludwig Graf (*Metallforschung*, 1947, 2, (7/8), 193–207).—A study was made of the stress-corrosion of homogeneous alloys, particularly those of silver or copper with gold. Preliminary experiments showed that traces of aluminium, magnesium, manganese, tin, and zinc, resulting from the use of deoxidizers, have no influence on the results. In practice, the alloys were prepared by melting *in vacuo* or under argon; the final specimens were in the form of hard-rolled strips, 0.6 mm. thick. The testing equipment is described. The results show that: (1) stress-corrosion can be caused only by a medium which attacks the solid solution; (2) the greatest stress-corrosion occurs in solid solutions based on a metal which is less noble than the alloying metal; and (3) the danger of stress-corrosion also exists with solid solutions based on a metal more noble than the alloying metal, but, in this case, the risk depends mainly on the type of corrosive medium. Thus, stress-corrosion takes place only when there is a reaction between the corrosive medium and at least one of the components of the solid solution, and its intensity bears a direct relationship to this reaction—it is limited by the electrochemical p.d. between the alloy components, their properties, and the type of reagent. The possibility, therefore, of producing alloys insensitive to stress-corrosion is limited to alloys based on gold, platinum, and palladium; alloys based on silver are only insensitive to stress-corrosion when they contain less-noble metals as the alloying component. Experiments using alloys of these metals, 2% aqueous ferric chloride as corrosive medium, and loads of 10–20 kg./mm.<sup>2</sup>, show that: (1) no stress-corrosion occurs with the unalloyed metal; and (2) stress-corrosion first occurs on addition of very small percentages of the alloying metal, increases to a maximum, decreases, and finally ceases above a definite amount of added metal. Thus, pure silver shows no stress-corrosion, but the addition of 1 at.-% gold produces it; it rises to a maximum at 21–27 at.-%, and then stops when ~45 at.-% gold has been added. Similarly, with copper-gold alloys, stress-corrosion is very intense up to ~30 at.-% gold, but ceases when the additions reach ~40 at.-%. In alloys formed from the customary base metals, where a p.d. exists between the components, stress-corrosion is a fundamental danger; it can only be minimized by: (a) special properties of the alloys, such as high plasticity or the formation of passive surface films, and (b) suitable treatment, such as annealing, cold working, or cladding.—E. N.

**\*On the Stress-Corrosion of Heterogeneous Alloys.** Ludwig Graf (*Metallforschung*, 1947, 2, (7/8), 207–212).—Although the stress-corrosion properties of heterogeneous alloys follow the same general rules as for homogeneous alloys (see preceding abstract), additional factors are introduced by the nature and amount of the individual phases present. These phases have two properties which are entirely independent of one another, namely their own sensitivity to stress-corrosion and purely chemical resistance to the corrosive medium. No danger of stress-corrosion exists only when there is complete chemical resistance to the corrosive medium. The heterogeneity of alloys may be divided into two classes: (1) grain-boundary heterogeneity, where the second phase is only in small amount; it is generally dis-

tributed round the grain boundaries; (2) structural heterogeneity, where about equal amounts of two phases are present. With grain-boundary heterogeneity the stress-corrosion properties depend only on the chemical resistance and sensitiveness to stress-corrosion of the minor phase, but with structural heterogeneity the following factors are of importance: (a) the relative amounts of the phases, (b) the electrochemical p.d. between the phases, one of which may be sensitive and the other insensitive to stress-corrosion, and (c) the nature of the corrosive medium. On this basis the differing corrosion properties of the aluminium-magnesium alloys compared with the aluminium-magnesium-zinc alloys are explained; the former have an intercrystalline phase,  $\text{Al}_3\text{Mg}_2$ , resistant to stress-corrosion but chemically unstable, whereas the latter have phases  $\text{Al}_2\text{Mg}_3\text{Zn}_3$  and  $\text{MgZn}_2$  which are very sensitive to stress-corrosion but very resistant chemically. A similar explanation is given for the properties of  $\alpha/\beta$  brass, gold-silver-copper, and gold-copper-nickel alloys.—E. N.

**\*Kinetics of the Reaction Between Copper and Aqueous Ammonia.** R. W. Lane and H. J. McDonald (*J. Amer. Chem. Soc.*, 1946, **68**, (9), 1699–1704).—The over-all reaction of copper and oxygen-saturated ammonium hydroxide is best presented as a zero-order reaction, and is largely controlled by diffusion. The reaction appears to be of first order with respect to ammonium hydroxide. Equations are formulated to show the relationship between the reaction velocity constant and the initial ammonium hydroxide. Variation in surface area of metal specimen does not influence the reaction rate per unit area. Energies of activation for the reaction of 0.3440 *M*-ammonium hydroxide on copper are  $k_1$  7100 cal.,  $k_2$  1670 cal. Corrections for the viscosity effect of the solvent raise these values to 12,850 and 7050 cal. Equations are formulated for the effect of linear velocity on the reaction rate. The reaction rate is retarded by increased viscosity. The reaction is composed of two separate zero-order reactions, the initial reaction being particularly chemically and diffusion controlled, and the later reaction being definitely diffusion controlled. Thermodynamic considerations and influence of ionic strength, varied by chloride ion addition, indicate that the rate-controlling step for the initial part of the reaction is  $\text{OH}^- + \text{OH}^- + \text{Cu}^0 = \text{X}^-$ .—AUTHORS.

**Tentative [A.S.T.M.] Method of Test for Copper Corrosion by Industrial Aromatic Hydrocarbons (D849-45T).** — (*Book of A.S.T.M. Standards*, 1946, (III), 997–998).

**\*Relation Between Corrosion Rates of Copper-Lead Bearing Alloys and Pure Lead in Solutions of Organic Acids in Hydrocarbons.** Carl F. Prutton and David Turnbull (*Corrosion and Material Protection*, 1947, **4**, (3), 13–18, 20).—Rates of corrosion of two types of copper-lead bearing alloys in air-saturated solutions of various organic acids in xylene and white oil were studied. The alloys were 65:35 copper-lead and 70.25:28.5:1.25 copper-lead-silver. The significance of certain variables is discussed, e.g. speed of rotation of test specimen; effect of depletion of lead from the alloy surface on the corrosion rate; character and concentration of the acid and the oxidizing agent; temp.; catalytic effect of salts formed during the reaction; and the ratio of the vol. of the test solution to the specimen area. It was found that with all other factors const., the rate of corrosion decreased steadily with loss of lead from the surface.—G. T. C.

**\*Stress-Corrosion of Manganese-Bronze Castings in Submarine Service.** Thomas L. Sheehan and Howard E. Dickerman (*J. Amer. Soc. Naval Eng.*, 1946, **58**, (4), 586–598; and (abridged) *Engineer*, 1947, **183**, (4761), 356–357).—An examination of records of failure of manganese-bronze castings in naval use showed that in each case the casting had been submerged in sea water in use, was of  $\beta$  structure, and had failed through intergranular cracks. The laboratory investigation subsequently carried out was designed to com-



pare the resistance to stress-corrosion in sea water of castings having  $\beta$  and  $\alpha/\beta$  microstructures. Three sets of specimens were prepared, basically of the Navy Dept. 49 B3e type (copper 55–60, lead 0.40 maximum, aluminium 1.50 maximum, manganese 3.50 maximum, iron 0.40–2.00, tin 1.00 maximum, other elements 0.20% maximum each, zinc remainder), with minor variations to produce the required microstructure. The first set was obtained from a  $\beta$ -bronze rocker arm which had failed in service, and the second and third sets from special heats calculated to produce  $\beta$  and  $\alpha/\beta$  microstructures, respectively. Specimens were immersed for given periods under load in sea water, the load being increased in successive steps until failure occurred. Full experimental data are given. Both types failed, but the  $\beta$  type was more susceptible than the  $\alpha/\beta$  type. The max. loads in excess of their yield strength withstood by the  $\beta$  and  $\alpha/\beta$  types, respectively, were 1594 and 8625 lb./in.<sup>2</sup>; the max. average elongations 1.9 and 8.4%, and the average immersion periods 4.31 and 82.25 days. Failures were intergranular for  $\beta$  bronze, and transcrystalline for  $\alpha/\beta$  bronze.—M. A. V.

**Some Case Histories of Corrosion Problems in Chemical Process Equipment [Nickel Alloys].** W. Z. Friend and F. L. LaQue (*Petroleum Eng.*, 1947, 18, (10), 212–220).—Seven cases involving unexpected corrosion are discussed. These mostly refer to nickel alloys. It is stressed that failure to recognize the presence of, or to anticipate the effects of, certain factors often leads to unexpected corrosion. Among the factors examined are: the importance of aeration or lack of it; temp. of the solution or metal; velocity; presence of minor, but highly corrosive, constituents; presence of constituents that destroy the protective film; absence of constituents expected to inhibit corrosion; unfortunate combinations of metals with unfavourable area ratios that lead to galvanic corrosion; concentration cells responsible for localized corrosion; and improper heat-treatment of the metal.—G. T. C.

**Zinc-Iron Couple in Water at Elevated Temperature.** George D. Lain (*Corrosion and Material Protection*, 1947, 4, (4), 12–15).—A review of the information available on the possibility of a reversal in potential of the zinc-iron couple in natural waters at elevated temp. No original work is described.—G. T. C.

**Hydrogen Attack on Metals at High Temperatures and Pressures.** J. Schuyten (*Corrosion and Material Protection*, 1947, 4, (5), 13–18).—A review of published information, which deals mainly with the attack by hydrogen on ferrous metals, but also mentions briefly attack on non-ferrous metals.

—G. T. C.

**\*Thermogalvanic Corrosion.—II.** R. M. Buffington (*Corrosion*, 1947, 3, (12), 613–631; discussion, 631).—Tests carried out on a Cu–Cu<sup>++</sup> cell showed that it was completely reversible, and that the potential between the electrodes was less than 0.3 mV. when the whole cell was at room temp. A thermodynamic analysis of thermogalvanic cells is given, and a table of calculated thermogalvanic potentials for various metal electrodes included. It is pointed out that in thermogalvanic corrosion, the oxidizing agent used up at the cathode is regenerated at the anode; and the significance of this in protection against corrosion is discussed.—M. A. V.

**\*Insulation of Dissimilar Metal Faying Surfaces.** Bernard W. Floersch (*Corrosion and Material Protection*, 1947, 4, (4), 16–18).—F. describes an investigation to determine the optimum organic insulation necessary for protection against galvanic corrosion of various combinations of dissimilar metals. The tests were carried out in salt spray and are not correlated with actual service conditions. Couples tested were: Duralumin–cadmium-plated steel; a magnesium alloy–Alclad; a magnesium alloy–18/8 stainless steel; a magnesium alloy–Duralumin. The aluminium materials were used in the anodized condition and the magnesium alloy was given a chromate

treatment. Zinc chromate primer was used as the organic protective coating.—G. T. C.

**Report of [A.S.T.M.] Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys.** — (Amer. Soc. Test. Mat. Preprint No. 10, 1947, 2 pp.).—Progress report.—R. L. B.

**Recommended [A.S.T.M.] Practice for Conducting Plant Corrosion Tests (A224-46).** — (Book of A.S.T.M. Standards, 1946, (1A), 491-497; appendix, 497-499).

**Expanding Corrosion-Testing Facilities at Kure Beach.** — (Corrosion and Material Protection), 1947, 4, (4), 7-9.—A description of the sea-water corrosion testing station established at Kure Beach, U.S.A., by the International Nickel Co. Atmospheric-exposure tests are also carried out to study the effect of salt-laden atmospheres. Methods of exposing the specimens and the materials used for making the racks, &c., are briefly described.—G. T. C.

**Corrosion Studies for the Petroleum-Refining Industry. I.—The Economic Aspects of Corrosion. II.—Factors Affecting Corrosion. III.—Corrosion Tests.** F. A. Rohrman (*Petroleum Refiner*, 1947, 26, (6), 85-90; (7), 93-98; (8), 109-113).—(I.—) A brief discussion of the economic aspects of corrosion, followed by an elementary introduction to corrosion theory. (II.—) R. deals in an elementary way with the factors affecting corrosion, dividing them into (a) metal, (b) corroding medium, and (c) external influences. (III.—) A general account of corrosion-testing procedures. R. describes various types of accelerated corrosion test and mentions the difficulty of interpreting the results obtained. He also briefly reviews methods of preventing corrosion.—G. T. C.

**Non-Ferrous [Copper and Bronze] Pipe Minimizes Sludge-Plant Corrosion.** — (*Petroleum Refiner*, 1947, 26, (3), 138).—Describes the use of copper and bronze in heating units, fittings, and control valves in a new sludge-circulating and heating plant for the disposal of acid sludge from petroleum refining.—G. T. C.

**Remedies Studied for Freakish Corrosion Occurring in Some Condensate Fields.** D. P. Thornton, Jr. (*Petroleum Processing*, 1947, 2, (4), 273-279).—A general review of three years' work of a Committee of the Natural Gasoline Association of America, dealing with corrosion in gas condensate wells and associated equipment. Mention is made of various non-ferrous materials.—G. T. C.

**\*Corrosion Tests in Distillation Equipment.** W. Z. Friend and J. F. Mason, Jr. (*Petroleum Eng.*, 1947, 18, (8), 192, 194, 198, 201, 204).—F. and M. describe tests in duplicate on 26 metals and alloys (11 ferrous, 15 non-ferrous) exposed in various positions in a number of types of refinery plant, including atmospheric crude distillation plant and equipment for separation, fractionation, and stabilization of the primary products from thermal cracking. Specimens in the form of discs were mounted in a spool-type holder, being separated from each other and from the metal parts of the spool by porcelain. Corrosion was assessed by weight loss after cleaning and removal of corrosion product, but depth of any pits and the presence of cracking and other forms of local attack were noted.—G. T. C.

**\*Corrosion of Filters in Sugar Refineries.** H. Inglesent and J. Anderson Storrow (*Indust. Chemist*, 1947, 23, (268), 291-297; (269), 373-379).—I. and S. discuss the corrosion of filters in glucose-processing plants and describe the results of potential measurements for various materials against an iron anode. The measurements were made in various sugar solutions of pH between 4.8 and 7.0, the materials studied being copper, brass, Monel metal, phosphor bronze, and stainless steel. In the second part of the paper, more refined potential measurements are described in which the chloride content



and sugar concentration were varied independently. The authors conclude that the p.d. against iron is affected principally by the sugar concentration and is relatively independent of chloride concentration. The materials examined can show considerable differences in electrode potential, and it is recommended that potential measurements be carried out on filter materials before installation; the actual plant liquor should be used in these tests.

—R. W. R.

**Chromate Corrosion Control for Engine-Jacket Water.** Marc Darrin (*Corrosion and Material Protection*, 1947, 4, (3), 6, 8–11).—The use of chromates and dichromates as inhibitors in various types of cooling system is discussed with particular reference to those used in connection with internal-combustion engines. Recommendations are made as to the quantities of chromate or dichromate required for various purposes, and data is included for chloride-containing waters. It is stated that in open systems treatment should start with a concentration of 500–1000 p.p.m., which may be reduced gradually to 200–400 p.p.m. after the formation of a protective film. In closed systems about 1000 p.p.m. is used. Sodium chromate is recommended for small systems, but for large ones sodium dichromate plus caustic soda is used on account of the lower cost.—G. T. C.

## VII.—PROTECTION

(Other than by Electrodeposition.)

**Surface-Treating Aluminium for Corrosion-Resistance and Finish-Adhesion.** — (*Modern Metals*, 1947, 3, (11), 16–18).—Describes the use of the Alodine process in the manufacture of recording instruments and control systems.

—N. B. V.

**Aluminium Flake Powders [for Paints].** Gunter W. Wendon (*Paint Manuf.*, 1947, 17, (11), 373–379).—The properties which aluminium powder must possess to make it suitable as a paint pigment are discussed. The effect of the method of manufacture of the powder on certain of these properties is also mentioned.—G. T. C.

**Aluminium Pigment Paste.** — (*Aeronaut. Mat. Specification (S.A.E.)*, 1947, (AMS 3128A).—A revised specification.—J. L. T.

**Standard [A.S.T.M.] Specifications for Aluminium Pigment Paste for Paint (D474–41).** — (*Book of A.S.T.M. Standards*, 1946, (II), 914–915).

**Tentative [A.S.T.M.] Specifications for Nickel and Nickel-Base-Alloy Clad Steel Plate (A265–43T).** — (*Book of A.S.T.M. Standards*, 1946, (IA), 1006–1010).

**Tentative [A.S.T.M.] Specifications for Lead Alloy Coating (Hot-Dip) on Iron or Steel Hardware (A267–46T).** — (*Book of A.S.T.M. Standards*, 1946, (IA), 1037–1040).

**Anodizing and Dye Colouring of Magnesium Die-Castings.** — (*Die-Castings*, 1947, 5, (10), 57–60).—A description of the Manodyz process, an electrolytic method for forming a magnesium oxide-silicate film. The physical properties of the coating and the production procedure are given. A dyed colour may be applied to this coating, and this operation is outlined.

—P. L.

**Chemical Surface Treatments for Magnesium.** — (*Metal Finishing*, 1948, 46, (1), 91).—Engineering Data Sheet.—J. L. T.

**\*Cathodic Protection of Steel Tank Bottoms by the Use of Magnesium Anodes.** J. R. James and R. L. Featherly (*Petroleum Technol.*, 1947, 10, (3); *A.I.M.M.E. Tech. Publ.* No. 2202, 7 pp.).—Details are given of the size, number, and distribution of magnesium anodes required for cathodically protecting a 20,000-barrel storage-tank bottom from external corrosion. Cur-

rent and potential measurements before and after installation of the anodes are given. The annual installation cost, spread over 15 years' expected life is about \$20, which amounts to 1% or less of the cost of replacing the tank bottom.—G. T. C.

**Discussion of Paper [by D. B. Good:] "Location and Selection of Anode Systems for Cathodic-Protection [Units]".** R. A. Brannon. O. C. Mudd (*Corrosion*, 1947, 3, (12), 632-635).—Cf. *ibid.*, (11), 539; see *Met. Abs.*, this vol., p. 240. M. gives anode-to-soil resistance data for a composite bed of anodes, and points out the danger of relying on calculation where conditions are irregular and the qualifying factors of a formula cannot be determined.

—M. A. V.

**Electroless Plating [of Nickel and Cobalt] on Metals by Chemical Reduction.** — (*Products Finishing*, 1947, 11, (12), 54-58).—Cf. *Met. Abs.*, this vol., p. 348. A review of recent work done by the U.S. National Bureau of Standards on immersion deposits of nickel, cobalt, and nickel-cobalt. An adherent coating is formed which is of good quality and generally bright, though brittle. The coating can be made hard and a suggested use is in applications where wear resistance is important. The solutions used are fairly complex and all contain a hypophosphite, which, with the catalytic initiation of the metal to be plated, reduces the nickel or cobalt salt to the metallic state. No reduction takes place except in the presence of iron or steel, nickel, gold, cobalt, palladium, or aluminium. The rate of deposition is 0.0002-0.0008 in./hr. Solutions are used hot, and pH needs fairly close control, but composition is not critical. Full details are given of two nickel baths, one cobalt bath, and one nickel-cobalt bath. The ductility of the deposits is improved by heating. The protective effect of the nickel coatings is about the same as for electrodeposited ones, but the cobalt coatings are inferior to electrodeposited cobalt.—G. T. C.

**\*A Protective Chemical Treatment for Tinplate.** R. Kerr (*J. Soc. Chem. Ind.*, 1946, 65, (4), 101-104).—When tinplate is immersed for 20 sec. at 85° C. in an alkaline phosphate-chromate solution containing a penetrating agent, it acquires an invisible film which protects it against blackening by sulphur-containing foods and also greatly retards rusting in moist air. An account is given of cannery trials in which the protective film was applied to tinplate cans after filling by adapting the can-washing machinery, and of a large-scale experiment in which tinplate sheets were treated by the same process before fabrication into cans. Cans manufactured from treated tinplate combine the advantages of freedom from internal blackening and increased resistance to external rusting, and for a number of packs the amount of tin absorbed by the food during storage is less than in tins made from untreated tinplate.

—AUTHOR.

**Zinc as an Anti-Corrosive.** A. H. Smart (*Paint Manuf.*, 1947, 17, (11), 383-385).—A short discussion on the electrochemical behaviour of zinc in preventing the corrosion of iron when in contact with it in an aqueous solution. Some simple experiments are also described which indicate that zinc exerts a certain protective effect even if there is no actual contact, possibly by raising the pH of the electrolyte. The use of zinc dust as a paint pigment is briefly mentioned.—G. T. C.

**Standard [A.S.T.M.] Specifications for Zinc (Hot-Galvanized) Coatings on Structural Steel Shapes, Plates, and Bars and Their Products (A123-33).** — (*Book of A.S.T.M. Standards*, 1946, (1A), 500-502).

**Standard [A.S.T.M.] Specifications for Zinc-Coated (Galvanized) Iron or Steel Sheets (A93-46).** — (*Book of A.S.T.M. Standards*, 1946, (1A), 503-507).

**Standard [A.S.T.M.] Specifications for Zinc-Coated (Galvanized) Iron on Steel Telephone and Telegraph Line Wire (A111-43).** — (*Book of A.S.T.M. Standards*, 1946, (1A), 508-511).



**Standard [A.S.T.M.] Specifications for Zinc-Coated (Galvanized) Iron or Steel Tie Wires (A112-33).** — (*Book of A.S.T.M. Standards, 1946, (IA), 512-514*).

**Standard [A.S.T.M.] Specifications for Zinc-Coated (Galvanized) Iron or Steel Farm-Field and Railroad Right-of-Way Wire Fencing (A116-39).** — (*Book of A.S.T.M. Standards, 1946, (IA), 515-517*).

**Standard [A.S.T.M.] Specifications for Zinc-Coated Iron or Steel Chain-Link Fence Fabric Galvanized After Weaving (A117-33).** — (*Book of A.S.T.M. Standards, 1946, (IA), 518-520*).

**Standard [A.S.T.M.] Specifications for Zinc-Coated (Galvanized) Iron or Steel Barbed Wire (A121-39).** — (*Book of A.S.T.M. Standards, 1946, (IA), 521-522*).

**Standard [A.S.T.M.] Specifications for Zinc-Coated Steel Wire Strand. "Galvanized" and Class A ("Extra-Galvanized") (A122-41).** — (*Book of A.S.T.M. Standards, 1946, (IA), 523-527*).

**Standard [A.S.T.M.] Specifications for Zinc-Coated Steel Wire Strand. Class B and Class C Coatings (A218-41).** — (*Book of A.S.T.M. Standards, 1946, (IA), 528-532*).

**Standard [A.S.T.M.] Methods of Test for Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles (A90-39).** — (*Book of A.S.T.M. Standards, 1946, (IA), 533-536*).

**Standard [A.S.T.M.] Method of Test for the Uniformity of Coating by the Preece Test (Copper Sulphate Dip) on Zinc-Coated (Galvanized) Iron or Steel Articles (A239-41).** — (*Book of A.S.T.M. Standards, 1946, (IA), 537-540, appendix, 541*).

**Standard [A.S.T.M.] Specifications for Zinc-Coated (Galvanized) Wrought Iron Sheets (A163-39).** — (*Book of A.S.T.M. Standards, 1946, (IA), 584-587*).

**Tentative [A.S.T.M.] Specifications for Zinc Coating (Hot-Dip) on Iron and Steel Hardware (A153-42T).** — (*Book of A.S.T.M. Standards, 1946, (IA), 1041-1043*).

**Corrosion and Preventive Methods in Katy Field.** R. C. Buchan (*Petroleum Eng.*, 1947, 18, (10), 159-172).—Corrosion problems in the producing and cycling equipment at this gas-condensate field are surveyed. B. deals mainly with ferrous metal corrosion, but mentions Stellite and hard chromium coatings for resisting erosion.—G. T. C.

**Corrosion Protection of Iron and Steel [by Sprayed Coatings].** — (*J. Inst. Automotive Eng. (Australia)*, 1946, 6, (10), 114-116).—Specifications of zinc and aluminium sprayed coatings are given for various lives and requirements under different conditions, such as marine, industrial, and immersion in fresh (hot and cold) and salt water.—A. B. W.

**Non-Ferrous Metals Aid in Steel's Use.** Jacob Levin (*J. Chem. Education*, 1946, 23, (3), 142-144).—A general review of the use of non-ferrous metals in the coating of steels.—S. G.

**Use of Glycerine in Metal Protection.** Georgia Leffingwell and Milton A. Lesser (*Corrosion and Material Protection*, 1947, 4, (3), 12, 22-23).—A review of the uses to which glycerine, either as such or as a constituent of glyptal paints, is used in metal finishing. Mention is made of its use in galvanizing, hot tinning, as an additive to plating baths, in anodizing, &c. 43 references are given.—G. T. C.

**Standard [A.S.T.M.] Method for Evaluating the Degree of Resistance to Blistering of Coatings of Paint, Varnish, Lacquer, and Related Products on Metal when Subjected to Immersion or Other Tests Involving Exposure to Moisture or Liquid (D714-45).** — (*Book of A.S.T.M. Standards, 1946, (II), 1171-1174*).

**The Metallizing of Glass and Plastics by the Reduction of Aqueous Solutions.** Patrick B. Upton (*J. Electrodepositors' Tech. Soc.*, 1947, 22, 45-72).—U. reviews the older processes and their newer modifications and collates the

new techniques now being employed and developed under the following heads: (1) preparation of surface, (2) general consideration of silvering processes and their applications, (3) particular silvering processes, (4) metals other than silver, and (5) metal films as a basis for electrodeposition. Data for some of the processes are summarized in tabular form, and a *bibliography* of 126 references, including earlier surveys of the subject, is included.

—A. B. W.

### VIII.—ELECTRODEPOSITION

**\*The Effect of the Basis Metal on the Electrodeposition of Brass.** W. D. Rae (*J. Electrodepositors' Tech. Soc.*, 1947, 22, 85-96).—Difficulties encountered in obtaining a satisfactory bond between rubber and brass plate are briefly mentioned, and the degree to which non-uniformity in the basis metal is responsible for some of these difficulties is discussed. Porosity in the basis metal may lead to inclusion of oil, cyanide, &c., which may modify the deposit considerably. Variations in the state of strain of the surface of the basis metal may also produce deposits which are non-uniform. The effect of heat-treatment at various temp. in improving the results is described. Chemical non-uniformity of the basis metal may also lead to poor adhesion.

—G. T. C.

**\*Blistering of Cadmium Plate on Soldered Steel.** E. R. Bowerman (*Monthly Rev. Amer. Electroplaters' Soc.*, 1947, 34, (9), 1026-1032).—A new type of blistering is described which occurs on cadmium-plated steel which has been soldered with a lead-tin solder. The blistering becomes noticeable at temp. above about 150° C. and spreads outwards from the soldered joint. Said to be due to the formation of a lead-tin-cadmium eutectic, it is particularly prevalent in coatings between 0.0005 and 0.0008 in. thick, though the dependence of the blistering on thickness is not satisfactorily explained.

—G. T. C.

**\*Fatigue Limit of Chromium-Plated Steel.** Louis Mehr, T. T. Oberg, and J. Teres (*Monthly Rev. Amer. Electroplaters' Soc.*, 1947, 34, (12), 1345-1359).—A report from the Materials Laboratory of the Air Material Command of the U.S. Army Air Forces, describing an investigation, the purpose of which was to study systematically and to evaluate the effect of possible variables on the fatigue limit of chromium-plated steel and also to develop a process that would cause such low fatigue loss that the necessity of testing each plated part could be dispensed with. Extensive numerical data are presented and the following conclusions reached: (1) Minimum reduction in fatigue strength for chromium plating to 0.001 in. thick without nitriding is approx. 8%. Reductions as high as 50% are found under unfavourable conditions. (2) Optimum conditions for high fatigue strength are: plate applied at 55° C. in the upper end of the bright-plating range; and the least favourable conditions are: 70° C. and low c.d. (3) At a given temp., the higher the c.d. the less is the reduction in fatigue properties. (4) Heating at 205° C. after plating reduces the fatigue limit in some cases. (5) Nitriding of the steel before plating improves the results. (6) Electrolytic polishing of the steel before plating produces a marked decrease in the fatigue limit. (7) Chromium plate cannot be applied indiscriminately to highly stressed areas subject to vibration. Application of chromium plate to a model subjected to a sufficient number of cycles to demonstrate serviceability is advocated in cases where stresses are indeterminate. A 30-million-cycle test is suggested as satisfactory for this purpose.—G. T. C.

**\*The Application of the Spekker Photo-Electric Absorptiometer to the Analysis of Chromium-Plating Solutions.** (Bayley). See p. 422.



**\*The Design and Use of a Photo-Electric Absorptiometer for the Analysis of Solutions Employed for the Electrodeposition of Hard Chromium.** (Styles). See p. 422.

**\*Copper Plating from Fluoborate Solutions.** Clifford Struyk and A. E. Carlson (*Monthly Rev. Amer. Electroplaters' Soc.*, 1946, **33**, (9), 923-934; correspondence, (12), 1306; also (condensed) *Canad. Metals*, 1946, **9**, (9), 22-24, 42; and *Metal Ind.*, 1946, **69**, (17), 348-352).—The effects are reported of variations in the content of copper, fluoboric acid, boric acid, and sodium and ammonium fluoborates on the limiting c.d., bath resistivity, and character of deposit. These results are compared with limiting c.d. and resistivity of copper sulphate baths. It is stated that the copper fluoborate bath permits of higher c.d. than any other bath, that anode and cathode efficiencies approach 100%, that control is simple, density and pH usually being sufficient, and that a cyanide strike must be used for materials that deposit copper by immersion. For normal work, the following bath has found wide application:  $\text{Cu}(\text{BF}_4)_2$  224 g./l. (copper 60 g./l.), pH (colorimetric) 1.2-1.7, temp. 80°-170° F. (27°-77° C.), limiting c.d. without agitation 150-350 amp./ft.<sup>2</sup> according to temp. Baths with double the above concentration have also been used with pH less than 0.6 at still higher c.d. The baths are prepared from the conc. copper fluoborate solution available commercially in the U.S.A.

—A. B. W.

**\*Copper Plating in Alkane Sulphonic Acid Baths.—II.** C. L. Faust, B. Agruss, E. L. Combs, and Wayne A. Proell (*Monthly Rev. Amer. Electroplaters' Soc.*, 1947, **34**, (6), 709-719).—Cf. *Met. Abs.*, this vol., p. 14. The throwing power, using the bent-cathode test, was investigated and compared with that of a Rochelle copper cyanide bath and two fluoborate baths. The alkane sulphonate bath was shown not to have particularly good throwing power—about the same as that of the fluoborate solutions and much inferior to that of the cyanide bath. Micrographic examination of the deposits showed that those from the sulphonate bath approached those from cyanide solutions in fineness of crystal size for the thinner coatings, but above 0.003-0.005 in. in thickness, the former tended to become coarse-grained. Columnar crystals were completely absent from the deposits. Sludge formation on the electrolytic copper anodes used was very marked, and bagging of the anodes is recommended. Iron and lead impurities in the solution have no serious deleterious effect. A faint odour is produced by the bath which would probably require the installation of a ventilating system in large plants. The authors conclude that this type of bath has definite commercial possibilities.

—G. T. C.

**\*Measurement of Thickness of Copper and Nickel Plate: A Comparison of Methods.** G. B. Bowman (*Monthly Rev. Amer. Electroplaters' Soc.*, 1947, **34**, (10), 1149-1151).—Results obtained for the thickness of nickel and copper coatings by a magnetic method and a chemical stripping method are compared with those obtained by direct microscopic measurement. In the case of nickel coatings, the two former methods give results which fall within roughly  $\pm 10\%$  of that given by the latter. With copper coatings between 0.001 and 0.002 in. thick there is little to choose between the three methods. On thin copper coatings there is considerable deviation.—G. T. C.

**\*Mechanical Properties of Nickel Deposits.** E. J. Roehl (*Monthly Rev. Amer. Electroplaters' Soc.*, 1947, **34**, (10), 1129-1140).—R. describes original work done on an all-chloride and a Watts-type nickel bath to obtain information on the mechanical properties of the deposits. The highest as-plated ductility, 37.3% on 1 in., was obtained in the Watts solution at pH 4.5. Annealing for 15 min. at 1400° F. (760° C.) increased this to 54.6%. Over-annealing caused marked loss in ductility. Annealing at 1400° F. for 15 min. increased the ductility of all deposits to about 50%, irrespective of pH, c.d., temp., and

composition of the depositing solution. With Watts solution at pH 2.0, c.d. has very little effect on the mechanical properties of as-plated nickel. At pH 5.0, the ductility remains const., but hardness and tensile strength both increase with decrease in c.d. The hardness and tensile strength of as-plated deposits decrease while the ductility increases with increase in solution temp., the effect being more pronounced at low than at high pH. Some photomicrographs are given which demonstrate the structure of the plate obtained under various conditions.—G. T. C.

**\*Smoothing Action as a Mechanism in Bright Nickel Plating.** G. E. Gardam (*J. Electrodepositors' Tech. Soc.*, 1947, 22, 155–168).—Data and photographs are presented which show that electrodeposits of nickel from solutions containing zinc, cadmium, or iron, made on a serrated cathode, are thicker in the hollows than on the crests. Bright nickel-plating solutions are shown to exhibit a similar smoothing action when they are used to deposit on a slightly matte surface. The mechanism of the brightening effect in each case is discussed.—G. T. C.

**\*The Quantitative Adhesion of Nickel Electrodeposits to Aluminium Alloys.** W. Bullough and G. E. Gardam (*J. Electrodepositors' Tech. Soc.*, 1947, 22, 169–188).—The adhesion of nickel deposits on a range of aluminium alloys was investigated, using a modified Hothersall–Leadbeater test described in an Appendix. Adhesion approx. equal to the ultimate tensile strength was obtained on commercial aluminium, Duralumin, R.R. 56, aluminium–copper (90 : 10), Birmabright, M.G. 7, and aluminium–silicon (90 : 10). The treatment was : (1) Etch at room temp. for 2–5 min. (10 min. for three classes of alloy above) in solution containing 10 vol.-% nitric acid (sp. gr. 1.42) and 10 vol.-% hydrofluoric acid (40%). (2) Whiten in 50 vol.-% nitric acid (sp. gr. 1.42), or dip for 4 min. in 98 vol.-% nitric acid with 2 vol.-% hydrofluoric acid in the case of aluminium–silicon alloys, and rinse. (3) Dip in sodium zincate solution for 2 min. and rinse (zincate solution for aluminium–magnesium and aluminium–silicon alloys contains zinc oxide 5, sodium hydroxide 10, and sodium potassium tartrate 500 g./l., and for all other alloys zinc oxide 5 and sodium hydroxide 45 g./l.). (4) Copper plate for a few minutes in cyanide, cathodes completing circuit on immersion, then rinse and nickel plate.—A. B. W.

**\*Determination of Impurities in Electroplating Solutions.** (A.E.S. Research Project No. 2.) IV.—Iron in Nickel-Plating Baths. (Serfass, Levine, Smith, and Duke). See p. 423.

**Adherent and Dense Heavy Silver Deposits.** Ralph A. Schaefer (*Monthly Rev. Amer. Electroplaters' Soc.*, 1946, 33, (11), 1176–1178).—The preparation of bearings and the plating of heavy silver deposits for subsequent machining and precision lead–indium plating is described. The operations are : trichloroethylene degreasing ; anodic electro-cleaning with proprietary bath at 40° C. with 40–80 amp./ft.<sup>2</sup> for about 6 min. ; pickling in 10–12% hydrochloric acid solution at 40°–45° C. for about 3 min. ; nickel striking in a modified Watts' type bath at 40°–45° C. with 20–30 amp./ft.<sup>2</sup> ; silver striking for 1–2 min. in a bath containing silver cyanide 0.75–1.5, sodium cyanide 35–45, and sodium carbonate 0–10 g./l., at room temp., plating in equipment previously described (R. A. Schaefer and J. B. Mohler, *Proc. 31st Ann. Conv. Amer. Electroplaters' Soc.*, 1943, 31, 29–31 ; *Met. Abs.*, 1946, 13, 176). Annealing at 325° F. (162° C.) or more is optional but unnecessary to obtain excellent adhesion. This is the last of a series of articles on heavy silver deposits.—A. B. W.

**\*Electro-Tinplate. I.—The Influence of Plating Conditions on the Quality of Electro-Tinplate Deposited from the Stannous Sulphate Bath.** R. M. Angles, K. W. Caulfield, and R. Kerr (*J. Soc. Chem. Ind.*, 1946, 65, (12), 430–433).—The conditions studied were : temp., c.d., tin and cresolsulphonic acid contents of the bath, and the effect of wetting agents ; the quality of the deposits was compared by means of thiocyanate and hot-water porosity tests and by



exposure in a humidity chamber. Quality improved with increase in tin content and decrease in c.d., but was impaired by raising the temp. Commercial wetting agents had no significant effect. In baths containing 30–40 g./l. tin, the optimum cresolsulphonic acid content was of the same order. In baths containing 10 g./l. tin, no improvement followed increases of cresolsulphonic acid content above 40 g./l.—A. B. W.

**Recent Developments in Tin and Tin Alloy Coatings.** John Ireland (*J. Sci. Indust. Research, India*, 1947, **6**, (8), 312–317).—Three developments are described: (1) Speculum plating, giving a hard and brilliant finish; (2) a tin–zinc alloy coating on steel, which resists corrosion better than tin or zinc alone and has better solderability than a zinc surface; and (3) an extra-thin coating of tin on steel, which is an excellent base for varnishes and lacquers and is also cheaper than grease as a rust preventive.—S. R.

**Zinc Alloy Die-Castings—Quality, Design, and Plating Procedures.** L. A. J. Lodder (*J. Electrodepositors' Tech. Soc.*, 1947, **22**, 199–205; discussion, 219–226).—L. stresses the importance of design, surface finish, and the absence of sub-superficial porosity in die-castings, particularly from the point of view of subsequent plating. The preparation of zinc-base alloys for plating, and suitable copper-plating solutions, are considered.—G. T. C.

**Pre-Treatment of Zinc Die-Castings Prior to Bright Nickel Plating.** P. Berger (*J. Electrodepositors' Tech. Soc.*, 1947, **22**, 207–218; discussion, 219–226; and (condensed) *Metal Ind.*, 1948, **72**, (5), 88–90; (7), 129–130).—A review of the various operations in preparing die-castings for electroplating, under the headings: degreasing, electro-cleaning, acid etching, and dipping. The importance of not “over-cleaning” is referred to. Also stressed is the need for proper choice of undercoat for bright nickel and chromium. Copper or brass are normally used and should not be less than 0.0003 in. thick in order to prevent contamination of plating solutions subsequently used. Copper is preferred to brass. Copper–tin alloy deposits are suggested as an alternative. Details of bath composition suitable for depositing such an alloy are given. It is claimed that thinner deposits may be used than the 0.0003 in. minimum mentioned for copper and that there is less risk of contaminating the nickel bath.—G. T. C.

**Bright Brass Plate on Zinc-Base Die-Castings.** Stanley J. Beyer (*Die-Castings*, 1947, **5**, (10), 60).—The procedure is described. No final buffing of the brass is required.—P. L.

**Drop Test for Determining Thickness of Zinc Coatings.** Richard Springer (*Monthly Rev. Amer. Electroplaters' Soc.*, 1947, **34**, (10), 1147).—An account of a method which has been widely used in Germany for many years. One drop of a solution containing 120 g./l. chromium trioxide and 35 g./l. sulphuric acid is placed on the degreased surface at 20° C. After 15 sec. it is removed rapidly with an absorbent cloth and replaced by another drop. The procedure is repeated at the same point until the base metal appears. Each drop applied for 15 sec. is equivalent to 0.000039 in. zinc. This figure applies to deposits from alkaline plating solutions containing sulphides. For deposits from other solutions a different factor has to be used.—G. T. C.

**Factors Affecting the Distribution of Electrodeposits.** N. A. Tope (*J. Electrodepositors' Tech. Soc.*, 1947, **22**, 29–44).—The subject is reviewed with citations of recent studies in this country and the U.S.A. T. concludes by advocating that greater attention should be paid to the primary current distribution and to the design of work and auxiliary racks, &c., for electrodeposition, rather than to striving for extreme throwing power.—A. B. W.

**Porosity of Electrodeposited Metals (A.E.S. Research Project No. 6).** II.—III.—Critical Literature Review. M. Thon and E. T. Addison, Jr. (*Monthly Rev. Amer. Electroplaters' Soc.*, 1947, **34**, (6), 722–730; (7), 831–842).—Cf. *Met. Abs.*, this vol., p. 16. (II.—) A comprehensive review of methods of

detecting individual pores, arranged under the following headings: hot-water tests, other tests for cathodic metal deposits, tests for anodic metal deposits, electrographic methods, salt-spray test, and impregnation methods. (III.—) A very full survey of methods of determining total porosity by chemical and physical means is given, followed by a discussion on the correlation between porosity and corrosion exposure tests and also between different types of porosity test. The results and conclusions of the porosity investigation are given, and a critical summary of the literature that has been reviewed for all the various coatings is presented. The causes and nature of porosity are considered under the headings: base-originating, suspension-originating, mechanical-originating, and intrinsic porosity. The causes of deposits failing to form on certain areas are examined as follows: unequal deposition from the beginning, local areas of poor electrical conductivity, loose particles, tiny gas bubbles, and surface roughness.—G. T. C.

**Report of [A.S.T.M.] Committee B-8 on Electrodeposited Metallic Coatings.**

—(Amer. Soc. Test. Mat. Preprint No. 15, 1947, 1-2).—Progress report.

—R. L. B.

**Engineering Electroforming.** M. H. Orbaugh (*Monthly Rev. Amer. Electroplaters' Soc.*, 1947, **34**, (7), 810-815).—O. considers the physical characteristics of deposits of copper, iron, and nickel from various baths. The various types of matrix that may be used include the permanent type, such as steel, brass, nickel, &c., and the non-permanent type, such as zinc and aluminium, which may be dissolved with acids, and lead alloys and waxes, which may be melted. The treatment of the matrix before commencing plating is briefly mentioned.—G. T. C.

**Laboratory Apparatus for Controlled Current Distribution on Small Flat Specimens.** J. B. Mohler and R. A. Schaefer (*Monthly Rev. Amer. Electroplaters' Soc.*, 1947, **34**, (12), 1361-1364).—The construction of cells for the preliminary laboratory investigation of electrodepositing solutions is considered. Cells are described which give either uniform or controlled varying c.d. They can be constructed so that they are little affected by the size and position of the anode, a fact which is of value in cases where the anode may cause polarization troubles or where it is desirable to have the anode at an appreciable distance from the cathode. The cells can be suspended directly in the plating bath.—G. T. C.

**Horizontal Plating Barrels and Auxiliary Equipment.** William H. Jackson (*Monthly Rev. Amer. Electroplaters' Soc.*, 1946, **33**, (11), 1162-1173).—The various types of equipment, arrangement of plant, and design of mechanized operations for balanced working are discussed in detail, but without reference to particular plating solutions.—A. B. W.

**Sources of Impurities in Electroplating Solutions.** Myron B. Diggin (*Monthly Rev. Amer. Electroplaters' Soc.*, 1947, **34**, (11), 1236-1242; and *Metal Ind.*, 1948, **72**, (3), 48-50).—Impurities in electroplating baths are discussed under the following headings: (1) inorganic, (2) organic, (3) solid and dispersed, and (4) gaseous.—G. T. C.

**Continuous Electrolytic Solution Purification.** C. E. Heussner and L. M. Morse (*Monthly Rev. Amer. Electroplaters' Soc.*, 1947, **34**, (11), 1243-1249; and *Metal Ind.*, 1948, **72**, (1), 6-8, 13).—It is claimed that the value of continuous electrolytic-bath purification in the production of deposits of uniformly good quality has been repeatedly demonstrated. The history of the development of this type of purification is briefly reviewed, and an account is given of how the method may be applied to a nickel-plating solution. The electrolytic purification unit is placed ahead of the filter and the heat exchanger. Provision is made for by-passing the purification unit when desired so that it will not interfere with pumping of the solution direct to a



storage or treatment tank. Full operating details are given of current requirements, cathode and anode sizes and arrangement, &c.—G. T. C.

**The Treatment of Plating- and Pickling-Shop Wastes.** E. W. Mulcahy (*J. Electrodepositors' Tech. Soc.*, 1947, 22, 227-242).—Details are given of the plant required for treating various liquid wastes, and of the use of flow recorders, weirs, and pH recorders in conjunction with it. Methods of dealing with iron, copper, chromates, and cyanides are described. Acid recovery is discussed and costs given to illustrate the advantages of installing an acid recovery plant. A plant for absorbing nitrous fumes from acid pickling processes is mentioned.—G. T. C.

**Industrial Housekeeping and Sanitation [in the Plating Shop].** John C. Soet (*Monthly Rev. Amer. Electroplaters' Soc.*, 1947, 34, (11), 1251-1261).—Includes information on the permissible concentration in the atmosphere of various substances used in the plating shop.—G. T. C.

**Corrosion-Resistant Cements in the Plating Room.** Vincent A. Curll (*Corrosion and Material Protection*, 1947, 4, (4), 19-20).—C. discusses the application of sodium silicate cements and phenol-formaldehyde synthetic-resin cements in the jointing of bricks, tiles, &c., exposed to corrosive chemicals.—G. T. C.

**Electroplating-Shop Costing.** A. W. Wallbank (*J. Electrodepositors' Tech. Soc.*, 1947, 22, 97-119).—The subject is considered in detail. It is claimed that existing methods of plating-shop costing are unsatisfactory and fail when the character or thickness of the deposit is altered. Segregation of total deposition costs from all other plating-shop costs is advocated. Details are given of the application of this method to still-vat plating, automatic and barrel plating, and also to anodizing and to ancillary plating-shop operations. Special overheads such as idle time, reject reclamation, shortages, &c., are discussed, and brief mention is made of an estimating method based on the costing system described.—G. T. C.

**New Pontiac Plating Plant.** ——— (*Monthly Rev. Amer. Electroplaters' Soc.*, 1947, 34, (8), 956-958).—A brief description of a modern, fully automatic plating plant.—G. T. C.

## IX.—ELECTROMETALLURGY AND ELECTROCHEMISTRY

(Other than Electrodeposition.)

**\*On the Potential of Aluminium in Aqueous Solutions of Sodium Chloride.** Georg Masing (*Metallforschung*, 1946, 1, (4/5), 97-110).—The polarization changes which occur with aluminium and Duralumin in an aqueous 3% sodium chloride solution, with and without additions of 1% sodium acetate as buffer, are described, together with the effect of oxygen content of the atmosphere and temp.—E. N.

**\*Photo-Galvanic Processes on a Gold Electrode.** V. Veselovsky (*Acta Physicochim. U.R.S.S.*, 1946, 21, (5), 803-835).—[In English]. See *Met. Abs.*, this vol., p. 242.—S. G.

**\*Production of Electrolytic Manganese.** D. S. Murthy and Y. D. Prasada Rao (*J. Sci. Indust. Research, India*, 1947, [B], 6, (3), 37-42).—The first part of the investigation deals with the extraction of manganese from its ores and the second with aqueous electrolysis. A canvas diaphragm cell rated at 50 lb. of manganese per 24 hr., is described. The anode is a 2% silver-lead alloy, and the cathode is of an alloy steel. The catholyte contains an optimum of 12 g. of manganese and 0.5M ammonium sulphate per litre. These concentrations are maintained by a feed liquor containing manganous sulphate 34-36, ammonium sulphate 135-140, and sulphur dioxide 0.15 g./l. The anolyte composition is approx. manganese 8-10,

ammonium sulphate 135–140, and sulphuric acid 43–50 g./l. The cell temp. is maintained at  $30^{\circ}\text{C.} \pm 2^{\circ}\text{C.}$  by circulating iced water through lead coils. The manganese obtained is of very high purity.—S. R.

**\*Motions of Electrolytes in Magnetic Field.** C. E. Swartz and W. van der Grinten (*Phys. Rev.*, 1946, [ii], 69, (5/6), 252).—Brief abstract of a paper presented to the American Physical Society. Further studies have been made of the motion of electrolytes in contact with metal in a magnetic field. It was previously shown (C. E. Swartz, *Phys. Rev.*, 1945, [ii], 67, 201) that the motion was due to current flow in the solution caused by p.d. which could be measured. The source of these p.d. is now proved to be simply voltaic cells set up at different parts of the same piece of metal. The phenomenon is only an unusual variation of those already discovered in the investigation of electrochemical corrosion. Application of a "ferroxyl indicator" (Walker, Cederholm, and Bent, *J. Amer. Chem. Soc.*, 1907, 29, 1256) shows regions of anodes and cathodes which confirm the readings taken with probes and potentiometer, and also predict the observed liquid movement in the magnetic field.—AUTHORS.

**Tentative [A.S.T.M.] Method for Determination of the pH of Aqueous Solutions with the Glass Electrode (E70-46T).** — (*Book of A.S.T.M. Standards*, 1946, (III A), 1229–1234).

## XI.—ANALYSIS

**\*Use of Bromate in Volumetric Analysis. IX.—Determination of Arsenic and Antimony by the Györy Method.** G. Frederick Smith (*J. Amer. Ceram. Soc.*, 1946, 29, (5), 142–145).—The determination of As and of Sb by the oxidation of the HCl solutions of their trivalent forms, using standard bromate as oxidant by the Györy method, has long been a preferred procedure. This method involves the use of strongly acid, hot solutions and non-reversible dyestuff indicators. Difficulties result from the instability of the indicators under the required conditions. The published improvements as applied to the Györy method are discussed and evaluated. The new study of the old procedure shows that the use of a hot solution is not required. The experimental proof of this conclusion is given, and the use of the "electron-beam spectrometer" and a modified "dead-stop" equivalence point determination is applied to establish the concordance between the potentiometric and visual-indicator applications. The performance of the various applicable internal indicators is described, and those preferred are specified.—AUTHOR.

**The Potentiometric Properties of Chromium.** B. G. Skinner (*J. Proc. Roy. Inst. Chem.*, 1947, (4), 170).—Summary of a paper read before the Sheffield, South Yorkshire, and North Midland Section of the Institute.—S. G. J.

**\*The Application of the Spekker Photo-Electric Absorptiometer to the Analysis of Chromium-Plating Solutions.** W. J. Bayley (*J. Electrodepositors' Tech. Soc.*, 1947, 22, 121–128).—The concentration of trivalent and hexavalent Cr in plating solutions can be estimated directly, using orange and blue filters respectively. The Fe is determined after the addition of potassium thiocyanate. Full details are given of the methods used, and a table showing the figures obtained on ten solutions, both chemically and by means of the Spekker absorptiometer, indicates excellent agreement between the two methods. The work refers to solutions ranging from 0–20 g./l. trivalent Cr, 200–350 g./l. hexavalent Cr, and 0–10 g./l. Fe, but should be applicable to the analysis of baths of other compositions.—G. T. C.

**\*The Design and Use of a Photo-Electric Absorptiometer for the Analysis of Solutions Employed for the Electrodeposition of Hard Chromium.** H. E. Styles (*J. Electrodepositors' Tech. Soc.*, 1947, 22, 129–154).—Cf. preceding



abstract. Before describing the instrument itself, S. gives an account of the causes of the changes which take place in the composition of Cr plating solutions during operation and goes on to consider the effects of these changes on the operation of the solution and on the deposit. Reference is also made to methods employed in correcting the composition of a solution whose composition has varied outside permissible limits. The desirability of rapid and accurate methods of determining the various constituents of the bath is mentioned, and the optical principles and constructional details of a photoelectric absorptiometer are given. The instrument varies in a number of particulars from the Spekker absorptiometer. Full descriptions are given of the methods used, and factors affecting the accuracy of the determinations are discussed. In addition to the estimation of trivalent and hexavalent Cr and of Fe, it is claimed that the instrument is particularly well suited for turbidometric estimations. Sulphate in the plating bath may be determined turbidometrically.—G. T. C.

**\*Determination of Impurities in Electroplating Solutions.** (A.E.S. Research Project No. 2.) IV.—Iron in Nickel-Plating Baths. Earl J. Serfass, W. S. Levine, G. Frederick Smith, and Frederick Duke (*Monthly Rev. Amer. Electroplaters' Soc.*, 1946, **33**, (11), 1189–1197).—Cf. *Met. Abs.*, this vol., p. 19. The development of an absorptiometric method of determining Fe as the ferrous *o*-phenanthroline complex is described. This involves: separation of Fe with cupferron in the cold using amyl acetate extraction; returning the Fe to aqueous solution by shaking the amyl acetate extract with 1:1 HNO<sub>3</sub>; reduction of Fe to ferrous state with hydroxylamine; addition of *o*-phenanthroline reagent and adjustment of pH with sodium acetate; and finally determination of the transmission on an absorptiometer. The results tend to be high, but are probably good enough for routine work. When only approx. estimates are desired, a comparison of the colour of the amyl acetate-Fe-cupferron solution with permanent colour standards will suffice, giving results to 0.015–0.020 g./l. Fe.—A. B. W.

**\*The Entrainment of Cobalt and Sulphur in Iron Separations.** E. T. Pinkney, R. Dick, and R. S. Young (*J. Amer. Chem. Soc.*, 1946, **68**, (6), 1126–1128).—Co and S are entrained to various degrees when Fe is separated by means of phosphate, NH<sub>4</sub>OH and NH<sub>4</sub> salts, or ZnO. A single phosphate separation leaves practically no Co or S in the precipitate. Separation of Fe with Na<sub>4</sub>OH and ammonium salts gives almost complete recovery of S in one precipitation, but Co is very strongly entrained and a large number of re-precipitations are necessary to liberate Co completely from Fe(OH)<sub>3</sub> in ammoniacal solution. Separation of Fe with ZnO, if the filtration is performed hot, yields most of the Co and S in one precipitation, though the recovery is not satisfactory, and for exact analyses a second precipitation is necessary. If filtration is done in the cold, the retention of Co is slightly increased, and the entrainment of S is very markedly increased.—AUTHORS.

**Reagents for Potassium.** Ronald Belcher (*Indust. Chemist*, 1947, **23**, (273), 673–680).—B. describes and assesses various methods for the detection and estimation of K. Reagents discussed include tartaric acid, chloroplatinic acid, perchloric acid, sodium cobaltinitrite, and their derivatives, and two recently introduced reagents, hexanitro-diphenylamine, and sodium-6-chloro-5-nitrotoluene-3-sulphonate. Several procedures for the use of each reagent are described, and a bibliography of 63 references is given.—R. W. R.

**\*Separation of the Rare-Earth Elements by Chloride Volatilization.** R. C. Vickery (*J. Soc. Chem. Ind.*, 1946, **65**, (12), 388–390).—Preliminary experiments demonstrated the possibility of separating binary mixtures of rare-earth chlorides by heating in a fused silica tube in a stream of Cl<sub>2</sub> at normal or reduced pressure (1 mm. Hg) and at temp. in the range 360°–450° C. for the latter pressure.—A. B. W.

**Reagents for Sodium. I.—Precipitation Methods Involving Uranium Salts.** Ronald Belcher (*Indust. Chemist*, 1946, 22, (263), 731-740).—B. critically reviews methods involving the use of reagents based on uranyl acetate. The removal of the interfering phosphate ion is discussed. A bibliography of 41 references is appended.—R. W. R.

**Reagents for Sodium.—II.—III.** Ronald Belcher (*Indust. Chemist*, 1947, 23, (264), 33-39; (267), 205-210).—Cf. preceding abstract. (II.—) A critical review of some miscellaneous methods for the estimation of Na, including titrimetric methods (both oxidation and reduction), colorimetric methods, the method of centrifugal measurement, polarographic methods, and the use of dihydroxytartaric acid and potassium caesium bismuth nitrite reagents. The review is based on 65 references to the literature. (III.—) An account of the use of a number of special reagents for the detection and estimation of Na. These include lithium ferrocyanide, fluosilicic acid, fluoalminic acid, resorcinol sulphonic acid, oxalic acid, and 6·8-dibromobenzoylene-urea. The chromatographic analysis of Na by violuric acid or 5-oxo-4-oximino-3-phenyl-iso-oxazolin is also described. A list of 19 references is appended.—R. W. R.

**\*Extraction of Vanadium from Aqueous Acid Solutions by Isopropyl Ether.** James J. Lingane and Louis Meithes, Jr. (*J. Amer. Chem. Soc.*, 1946, 68, (12), 2443-2447).—V is extracted by isopropyl ether from its solutions in HCl and H<sub>2</sub>SO<sub>4</sub> in the form of a vanadic acid. Extraction from solutions originally containing the V in the quadrivalent state is initially very small, but increases with time as the V is oxidized by peroxide photolytically formed in the ether. Extraction from HCl solutions originally containing the V in quinquevalent state is initially large, but decreases as the vanadate is reduced by chloride ion. Peroxyvanadic acid is not extracted from H<sub>2</sub>SO<sub>4</sub> solutions by isopropyl ether. The optimum conditions for the quantitative separation of ferric iron from V by an isopropyl ether extraction have been defined as follows: the V must be present in the quadrivalent state, the isopropyl ether must be peroxide-free, the extraction must be completed within about 10 min., and the HCl concentration should be between 7 and 8M. Under these conditions a very complete separation is obtained.

—AUTHORS.

**Colorimetric Determination of Aluminium in Zinc-Base Die-Casting Alloys.** Milton Sherman (*Die-Castings*, 1947, 5, (10), 23, 42-44).—S. describes a method developed using alizarin red S.—P. L.

**\*The Spectrochemical Analysis of Nickel Alloys.** E. K. Jaycox (*Bell Teleph. System Tech. Publ.*, 1947, Monograph B-1459, 4 pp.).—See *Met. Abs.*, this vol., p. 158.—J. L. T.

**\*The Application of the Curved-Crystal Spectrograph to the Chemical Analysis of Alloys.** Jack Ball and F. C. Blake (*Phys. Rev.*, 1946, [ii], 69, (11/12), 703).—Brief abstract of a paper presented to the American Physical Society. It was found, by using a beam of X-rays from a Mo target, that fluorescent radiation from various elements could be quite easily registered by the curved-crystal spectrograph. The L-series for W and Pb, as well as the K-series for Cu and Zn were obtained. By using a series of bronzes of different compositions, the K lines for Cu and Zn were obtained even down as low as 3% for Zn. This method could be applied to solid sections, metallic coatings, &c., without damage to the materials.—AUTHORS.

**Tentative [A.S.T.M.] Recommended Practices for Apparatus and Reagents for Chemical Analysis of Metals (E50-46T).** — (Book of A.S.T.M. Methods of Chem. Analysis of Metals, 1946, 1-31).

**Tentative [A.S.T.M.] Method of Sampling Wrought Non-Ferrous Metals and Alloys for Determination of Chemical Composition (E55-46T).** — (Book of A.S.T.M. Methods of Chem. Analysis of Metals, 1946, 141-143).

**Standard [A.S.T.M.] Methods of Chemical Analysis of Aluminium and Aluminium-Base Alloys (E34-45).** — (*Book of A.S.T.M. Methods of Chem. Analysis of Metals*, 1946, 144-162).

**Standard [A.S.T.M.] Methods of Chemical Analysis of Magnesium and Magnesium-Base Alloys (E35-45).** — (*Book of A.S.T.M. Methods of Chem. Analysis of Metals*, 1946, 163-179).

**Tentative [A.S.T.M.] Method of Chemical Analysis of Copper : Electrolytic Determination of Copper (E53-46T).** — (*Book of A.S.T.M. Methods of Chem. Analysis of Metals*, 1946, 180-182).

**Standard [A.S.T.M.] Methods of Chemical Analysis of Brasses (E36-45).** — (*Book of A.S.T.M. Methods of Chem. Analysis of Metals*, 1946, 183-196).

**Tentative [A.S.T.M.] Methods of Chemical Analysis of Special Brasses and Bronzes (E54-46T).** — (*Book of A.S.T.M. Methods of Chem. Analysis of Metals*, 1946, 197-219).

**Standard [A.S.T.M.] Methods of Chemical Analysis of Pig Lead (E37-45).** — (*Book of A.S.T.M. Methods of Chem. Analysis of Metals*, 1946, 220-231).

**Tentative [A.S.T.M.] Methods of Chemical Analysis of Lead- and Tin-Base Solder Metal (E46-46T).** — (*Book of A.S.T.M. Methods of Chem. Analysis of Metals*, 1946, 232-241).

**Tentative [A.S.T.M.] Methods of Chemical Analysis of White-Metal Bearing Alloys (E57-46T).** — (*Book of A.S.T.M. Methods of Chem. Analysis of Metals*, 1946, 242-251).

**Standard [A.S.T.M.] Methods of Chemical Analysis of Silver Solders (E56-45).** — (*Book of A.S.T.M. Methods of Chem. Analysis of Metals*, 1946, 252-259).

**Tentative [A.S.T.M.] Method of Sampling Slab Zinc (Spelter) (E65-46T).** — (*Book of A.S.T.M. Methods of Chem. Analysis of Metals*, 1946, 260-261).

**Standard [A.S.T.M.] Methods of Chemical Analysis of Slab Zinc (Spelter) (E40-45).** — (*Book of A.S.T.M. Methods of Chem. Analysis of Metals*, 1946, 262-269).

**Tentative [A.S.T.M.] Method for Polarographic Determination of Lead and Cadmium in Zinc (E68-46T).** — (*Book of A.S.T.M. Methods of Chem. Analysis of Metals*, 1946, 270-271).

**Standard [A.S.T.M.] Methods of Chemical Analysis of Zinc-Base Die-Casting Alloys (E47-45).** — (*Book of A.S.T.M. Methods of Chem. Analysis of Metals*, 1946, 272-280).

**Standard [A.S.T.M.] Methods of Chemical Analysis of Nickel (E39-45).** — (*Book of A.S.T.M. Methods of Chem. Analysis of Metals*, 1946, 281-293).

**Tentative [A.S.T.M.] Methods of Chemical Analysis of Metallic Materials for Electrical Heating (E38-42T).** — (*Book of A.S.T.M. Methods of Chem. Analysis of Metals*, 1946, 294-309).

**Tentative [A.S.T.M.] Recommended Practice for Photometric Methods for Chemical Analysis of Metals (E60-46T).** — (*Book of A.S.T.M. Methods of Chem. Analysis of Metals*, 1946, 310-320).

**Tentative [A.S.T.M.] Photometric Methods for Chemical Analysis of Magnesium and Magnesium-Base Alloys (E61-46T).** — (*Book of A.S.T.M. Methods of Chem. Analysis of Metals*, 1946, 321-330).

**Tentative [A.S.T.M.] Photometric Methods for Chemical Analysis of Copper and Copper-Base Alloys (E62-46T).** — (*Book of A.S.T.M. Methods of Chem. Analysis of Metals*, 1946, 331-342).

**Tentative [A.S.T.M.] Photometric Method for Determination of Iron in 70 : 30 Copper-Nickel Alloy (E63-46T).** — (*Book of A.S.T.M. Methods of Chem. Analysis of Metals*, 1946, 343-344).



**Tentative [A.S.T.M.] Photometric Method for Determination of Bismuth in Pig Lead (E58-45T).** — (*Book of A.S.T.M. Methods of Chem. Analysis of Metals*, 1946, 345-347).

**Tentative [A.S.T.M.] Photometric Method for Determination of Iron in Leaded Tin-Base Alloys (E67-46T).** — (*Book of A.S.T.M. Methods of Chem. Analysis of Metals*, 1946, 348-350).

**Tentative [A.S.T.M.] Photometric Methods for Determination of Iron in Slab Zinc (Spelter) (E64-46T).** — (*Book of A.S.T.M. Methods of Chem. Analysis of Metals*, 1946, 351-355).

**Tentative [A.S.T.M.] Method of Quantitative Spectrochemical Analysis of High-Grade Pig Lead (E25-37T).** — (*Book of A.S.T.M. Methods of Chem. Analysis of Metals*, 1946, 356-360).

**Tentative [A.S.T.M.] Method of Spectrochemical Analysis of Lead Alloys for Minor Constituents and Impurities (E49-93T).** — (*Book of A.S.T.M. Methods of Chem. Analysis of Metals*, 1946, 361-363).

**Tentative [A.S.T.M.] Method of Spectrochemical Analysis of Tin Alloys for Minor Constituents and Impurities (E51-43T).** — (*Book of A.S.T.M. Methods of Chem. Analysis of Metals*, 1946, 364-366).

**Tentative [A.S.T.M.] Method of Spectrochemical Analysis of Zinc for Lead, Iron, and Cadmium (E26-43T).** — (*Book of A.S.T.M. Methods of Chem. Analysis of Metals*, 1946, 367-370).

**Tentative [A.S.T.M.] Method of Spectrochemical Analysis of Zinc Alloy Die-Castings for Minor Constituents and Impurities (E27-43T).** — (*Book of A.S.T.M. Methods of Chem. Analysis of Metals*, 1946, 371-377).

**Standard [A.S.T.M.] Methods of Chemical Analysis of Zinc Dust (Metallic Zinc Powder) (D521-40).** — (*Book of A.S.T.M. Standards*, 1946, (II), 983-985).

**Standard [A.S.T.M.] Methods of Chemical Analysis of Industrial Metal-Cleaning Compositions (D800-45).** — (*Book of A.S.T.M. Standards*, 1946, (III<sub>A</sub>), 441-456).

**Standard [A.S.T.M.] Methods of Sampling Plant or Confined Waters for Industrial Uses (D510-41).** — (*Book of A.S.T.M. Standards*, 1946, (III<sub>A</sub>), 457-462).

**Standard [A.S.T.M.] Method for the Determination of the Calcium Ion and Magnesium Ion in Industrial Waters (D511-42).** — (*Book of A.S.T.M. Standards*, 1946, (III<sub>A</sub>), 463-466).

**Standard [A.S.T.M.] Method of Reporting Results of Analysis of Industrial Waters (D596-46).** — (*Book of A.S.T.M. Standards*, 1946, (III<sub>A</sub>), 480-483).

**Standard [A.S.T.M.] Method of Test for Colorimetric Determination of Small Amounts of Copper and Manganese in Textiles (D377-37).** — (*Book of A.S.T.M. Standards*, 1946, (III<sub>A</sub>), 509-512).

**Tentative [A.S.T.M.] Methods of Chemical Analysis for Lead, Copper, and Iron in Lubricating Oils (D810-44T).** — (*Book of A.S.T.M. Standards*, 1946, (III<sub>A</sub>), 892-897).

**Tentative [A.S.T.M.] Methods of Chemical Analysis for Metals in Lubricating Oils (D811-44T).** — (*Book of A.S.T.M. Standards*, 1946, (III<sub>A</sub>), 901-912).

**Tentative [A.S.T.M.] Method of Test for Total Aluminium and Aluminium Ion in Industrial Waters (D857-45T).** — (*Book of A.S.T.M. Standards*, 1946, (III<sub>A</sub>), 1017-1019).

**Tentative [A.S.T.M.] Method of Test for Manganese in Industrial Waters (D858-45T).** — (*Book of A.S.T.M. Standards*, 1946, (III<sub>A</sub>), 1036-1037).

**Tentative [A.S.T.M.] Method of Test for Volumetric Determination of Small Amounts of Copper in Textiles (D463-37T).** — (*Book of A.S.T.M. Standards*, 1946, (III<sub>A</sub>), 1111-1113).

**XII.—LABORATORY APPARATUS, INSTRUMENTS, &c.**

(See also "Testing" and "Temperature Measurement and Control".)

**An Illuminator for Use in Metallographic Microscopy.** Ernest E. Fairbanks (*J. Opt. Soc. Amer.*, 1946, **36**, (4), 244).—S. G.**Conditions for Extending the Resolution Limit of the Electron Microscope.** V. E. Cosslett (*J. Sci. Instruments*, 1947, **24**, (2), 40-43).—The limiting resolution obtainable with magnetic lenses of existing type may be reduced below 10 Å by the use of a sufficiently high accelerating voltage, provided that the lens power is maintained at a value which gives minimum aberration. This may be achieved either by increasing simultaneously the strength of the magnetic focusing field in a lens of fixed dimensions, or by increasing lens dimensions at a given value of field strength. In either case a resolving limit of 5-6 Å is predicted: in the first case for a field of 25,000 oersteds and a voltage of 350 kV. at a focal length of 2 mm., and in the second case at a focal length of 9 mm. and a voltage of 1 mV. at a field strength of 10,000 oersteds. Further improvement in resolution is only to be obtained by correction of lens aberrations.—AUTHOR.**\*Thermal Conductivity of Metals at High Temperatures. I.—Description of the Apparatus and Measurements on Iron.** (Armstrong and Dauphinee). See p. 390.**An Easily Constructed All-Metal Vacuum Gauge.** Robert T. Webber and C. T. Lane (*Rev. Sci. Instruments*, 1946, **17**, (8), 308).—A simple modification of a thermocouple-Pirani type of gauge which will indicate pressures from 1 to  $10^{-3}$  mm. of mercury is described.—J. C. C.**The New Muirhead Direct-Reading pH Meter.** R. H. Thorp (*Instrument Practice*, 1947, **1**, (4), 132-134).—P. L.**\*An Electromagnet for Non-Magnetic Substances.** William Vail Lovell (*Phys. Rev.*, 1946, [ii], **69**, (5/6), 251).—Brief abstract of a paper presented to the American Physical Society. The A.C. electromagnet described is effective on armatures of non-magnetic conducting substances, being able to attract objects from an appreciable distance. In addition to attracting magnetic material, the device attracts and holds such diverse objects as a silver coin, an aluminium cup, a roll of copper wire, &c. The operation depends on the well known phenomena of attraction and repulsion between conductors carrying current. In the simplest form, an alternating-flux field induces currents of substantially like phase in a fixed member (called the attractor) and in a conducting object adjacent to the attractor. The zone of attraction is roughly a cone having its base in the surface of the structure and its apex in the axis extended. A non-magnetic conducting object situated so that the principal induced currents lie within the zone is attracted, otherwise it is repelled. In one form characterized by relatively short coils and conductive, rather than inductive, energization of the attractor element, there is a region of attraction between inner and outer zones of repulsion.—AUTHOR.**Densitometers.** — (*Instrument Practice*, 1947, **2**, (1), 25-26).—A brief outline of the principles of the densitometer, an instrument used for the evaluation of the relative densities of spectral lines, is illustrated by a description of an instrument developed by the General Electric Company of Schenectady.—P. L.**\*Correction of X-Ray Powder Diffraction Films for Non-Uniform Shrinkage.** Howard H. Claassen and Karl E. Beu (*Rev. Sci. Instruments*, 1946, **17**, (8), 307).—Films do not shrink uniformly, particularly if they are not dried evenly, and thus errors may be caused if measurements are made only from knife-edge images near the ends. A better method is to mill scratches at

regular intervals of 5 mm. in the camera body next to the film on the side towards the specimen. The scratches appear on the film as points on the edge of the background fogging. By taking readings of the point nearest each diffraction line, individual corrections can be applied to each line reading.

—J. C. C.

**\*Thin-Walled Plastic Capillaries for X-Ray Diffraction Use.** Jerry M. Waite (*Rev. Sci. Instruments*, 1946, 17, (8), 557).—Clean annealed copper wire 0.45 or 0.75 mm. in dia. is rubbed with graphite powder and dipped twice in 10% solution of parlodion in amyl acetate. When dry, the capillaries are removed by stretching the wire.—J. C. C.

**High-Temperature X-Ray Diffraction Camera.** Frank G. Chesley (*Rev. Sci. Instruments*, 1946, 17, (8), 558).—The use of interchangeable film holders 57.3 and 114.6 mm. in dia. to permit exploratory and detailed work to be done with the same camera is noted.—J. C. C.

**\*A Method for Controlling Scattered Radiation in Obtaining X-Ray Absorption Data by Photographic Means.** H. E. Seemann and L. L. MacGillivray (*Rev. Sci. Instruments*, 1946, 17, (12), 539–542).—When measuring the X-ray absorption of filter materials (as in step-wedge measurements), scattered radiation may be eliminated by placing a lead chamber having parallel longitudinal compartments between the filters and the films.—J. C. C.

### XIII.—PHYSICAL AND MECHANICAL TESTING, INSPECTION, AND RADIOLOGY

**Modern Methods of Testing.** A. E. Bingham (*J. Trans. Soc. Eng.*, 1946, 47, (2), 91–99; discussion, 99–101).—S. G.

**Recommended [A.S.T.M.] Practice for Short-Time Elevated-Temperature Tension Tests of Metallic Materials (E21-43).** — (*Book of A.S.T.M. Standards*, 1946, (IA), 728–734).

**Recommended [A.S.T.M.] Practice for Conducting Long-Time High-Temperature Tension Tests of Metallic Materials (E22-41).** — (*Book of A.S.T.M. Standards*, 1946, (IA), 735–738; appendix, 739–740).

**\*Hardness Testing of Metals and Alloys at Elevated Temperatures.** Frederick P. Bens (*Trans. Amer. Soc. Metals*, 1947, 38, 505–513; discussion, 513–516; and (summary) *Indust. Diamond Rev.*, 1947, [N.S.], 7, (80), 206–207).—Equipment for making diamond pyramid hardness tests on specimens maintained at temp. up to 925° C. in a vacuum chamber is described and illustrated. The assembly utilizes the loading device and optical system of a standard Vickers machine. A device is incorporated for moving the specimen under the indenter without destroying the vacuum. Good correlation has been found between the hardness at 870° C. and the stress-rupture life under 20,000 and 24,000 lb./in.<sup>2</sup> at the same temp. for a number of chromium-base alloys.—J. C. C.

**\*The Measured Knoop Hardness of Hard Substances and Factors Affecting Its Determination.** Newman W. Thibault and Helen L. Nyquist (*Trans. Amer. Soc. Metals*, 1947, 38, 271–323; discussion, 323–330; and (summary) *Indust. Diamond Rev.*, 1947, [N.S.], 7, (80), 198–203).—Experience in the use of the Tukon tester with a Knoop indenter for measuring the hardness of hard brittle substances is discussed, with special reference to possible sources of error. Specimens must be carefully polished with as little cold working of the surface as possible. Inertial loads caused low readings in early machines; the solenoid and torque-arm devices which are now fitted overcome this trouble. Slight nicks on the edge of the indenter may cause errors and may be detected by periodic check tests on a standard sample. The optical equipment used for measuring the indentations has a marked effect on the readings,



the longest apparent indentations being obtained with lens systems of the highest resolving power. The Knoop hardness may vary very greatly with crystallographic orientation. Errors may occur from asymmetrical impressions if the length of the shorter diagonal is less than 80% of the longer, and indentations should preferably be not closer than 1.5 times the indentation length. The load should always be specified.—J. C. C.

**\*Precision Determination of Stress-Strain Curves in the Plastic Range.** John R. Low, Jr., and Frank Garofalo (*Proc. Soc. Exper. Stress Analysis*, 1947, 4, (2), 16-24).—A method is described for the determination of simple tension stress-strain curves in the plastic range with high precision. The apparatus used consisted of a ring dynamometer to measure loads and a straight beam "clip gauge" to measure strain; in both instruments SR-4 strain-gauges were used indirectly to indicate load and strain values. The clip gauge had a max. capacity of 0.7 in. extension (35% elongation on a 2-in. gauge-length) and a sensitivity of 0.0001 in. extension. The two dynamometers used had a max. capacity of 1300 lb. and 2500 lb. and a sensitivity of 1 lb. and 2 lb., respectively. The analytical expression ( $\sigma = K\delta^n$ ) relating true stress ( $\sigma$ ) and true strain ( $\delta$ ) in the plastic range in simple tension is discussed. When using the method described, the material constant  $n$ , for a single grade of steel, was found to be reproducible in 48 tests within  $\pm 1.7\%$  and the  $K$  value within  $\pm 1.9\%$ . The material constants  $K$  and  $n$  for a number of different materials (steels and 2 aluminium alloys) are reported, together with typical logarithmic stress-strain curves.—AUTHORS.

**Yield-Stress Determination Without Stress-Strain Curves.** L. J. Ebert, M. L. Freid, and A. R. Toole (*Engineer*, 1948, 185, (4805), 208-209; and *Metal Ind.*, 1947, 71, (4), 67-69).—Summaries of a paper published in *Bull. Amer. Soc. Test. Mat.*, 1947, (145), 50-52, and of the further discussion, *ibid.*, 1947, (148), 94-96. See *Met. Abs.*, this vol., p. 25.—S. G.

**Proof-Stress [Determination].** Arthur Fisher ([*Monthly*] *J. Inst. Metals News Section*), 1946, (Sep.), xxiii-xxiv).—A letter suggesting that British Standard Specification No. 18-1938 (amended June 1940), which defines proof stress and gives methods of determination, should be modified.—J. L. T.

**Report of [A.S.T.M.] Committee A-6 on [Testing of] Magnetic Materials.** — (*Amer. Soc. Test. Mat. Preprint No. 5*, 1947, 1-3).—Progress report. —R. L. B.

**Proposed Tentative [A.S.T.M.] Method of Test for Permeability of Paramagnetic Materials.** — (*Amer. Soc. Test. Mat. Preprint No. 5*, 1947, 4-5).—This method of test covers the measurement of paramagnetic materials having a permeability of less than 1.05, and should be accurate within  $\pm 8\%$  or  $\pm 0.0001$ .—R. L. B.

**Standard [A.S.T.M.] Methods of Testing Magnetic Materials (A34-36).** — (*Book of A.S.T.M. Standards*, 1946, (IA), 647-673).

**Standard [A.S.T.M.] Definitions of Terms with Symbols Relating to Magnetic Testing (A127-46).** — (*Book of A.S.T.M. Standards*, 1946, (IA), 674-681).

**Tentative [A.S.T.M.] Methods of Core-Loss Test for Frequencies up to 2000 Cycles and Ductility Tests of Magnetic Materials (A34-46T).** — (*Book of A.S.T.M. Standards*, 1946, (IA), 1085-1091).

**Report of [A.S.T.M.] Committee B-1 on [Copper] Wires for Electrical Conductors.** — (*Amer. Soc. Test. Mat. Preprint No. 8*, 1947, 3 pp.).—Provisions of standard specifications for medium-hard-drawn and hard-drawn copper wire, and hard-drawn copper alloy wire, and a revision of the tentative specification for rope-lay-standard copper conductors having concentric-standard members, are presented.—R. L. B.

**Report of [A.S.T.M.] Committee B-2 on Non-Ferrous Metals and Alloys.** — (*Amer. Soc. Test. Mat. Preprint No. 9*, 1947, 3 pp.).—Recommendations

of tentative specifications for fire-refined copper for wrought alloys, white-metal bearing alloys, and soft-solder metal have been accepted, and tentative specifications for oxygen-free electrolytic-copper wire, bars, billets, and cakes, have been adopted.—R. L. B.

**Report of [A.S.T.M.] Committee B-4 on Electrical-Heating, [Electrical-] Resistance, and Related Alloys.** — (*Amer. Soc. Test. Mat. Preprint No. 11*, 1947, 1-2).—Progress report.—R. L. B.

**Proposed Tentative [A.S.T.M.] Methods of Testing Fine Round and Flat Wire for Electronic Devices.** — (*Amer. Soc. Test. Mat. Preprint No. 11*, 1947, 9-12).—Procedures for the testing of fine wire approx. 0.010 in. dia. or thick, used in electronic devices and lamps, for roundness, edgewise curvature (of ribbon), straightness, and tensile and electrical-resistivity properties are outlined.—R. L. B.

**Report of [A.S.T.M.] Committee B-5 on [Testing of] Copper and Copper Alloys, Cast and Wrought.** — (*Amer. Soc. Test. Mat. Preprint No. 12*, 1947, 34 pp.).—Details of the revision of 25 tentative specifications and the revision of 20 standard specifications for copper and copper-base alloys are adopted by the Committee. Proposed tentative methods for the tensile testing of copper and copper alloy rods, bars, and shapes, covering the apparatus, specimens, and procedures for testing, are accepted. The ends of the specimen may be flattened to facilitate fracture, and the gripping devices are shown. The speed of testing while within the elastic limit is important with some of the materials, and methods for determining the yield points are defined.—R. L. B.

**Fatigue Failures in Aircraft.** K. Arnstein (*Proc. Soc. Exper. Stress Analysis*, 1946, 3, (2), 124-130).—A. presents a review of the Goodyear Aircraft Corporation's efforts in airframe fatigue testing, using a resonant-type fatigue machine suitable for testing girders, tubes, and structural shapes for axial pulsating, or alternating loads at 2400-6000 cycles/min.; a cathode-ray oscilloscope registered imposed stresses. Flexural-fatigue test curves were developed for three high-strength aluminium alloys. By pre-stressing the members in tension all failures could be made to yield in tension. Welded, riveted, and bonded joints were also explored with this equipment. A stress-change recorder was developed for the measurement of non-cyclic loads on parts in aircraft.—R. L. B.

**Amount Gained in Fatigue Strength of Machine Parts by Using a Material of Higher Tensile Strength.** R. E. Peterson (*Proc. Soc. Exper. Stress Analysis*, 1946, 3, (2), 149-151).—The effect of stress raisers on the endurance of finished parts is discussed.—R. L. B.

**\*Fatigue Failures in Telephone-Apparatus Parts.** J. R. Townsend (*Proc. Soc. Exper. Stress Analysis*, 1946, 3, (2), 161-166).—The Bell Telephone Laboratories have developed a series of fatigue machines to search for the most suitable design and the material to be used for cantilever springs for electrical apparatus. The simplest design for the spring evolved was the best. Goodman diagrams are being drawn up for all common non-ferrous metals in all hardnesses. Fatigue tests were also made on lead and lead-base alloys for cable sheaths. Working stresses encountered in service were measured by electromagnetic strain-gauges on an aerial cable. The largest deflection was caused by the daily fluctuation in temp. (40° F.), causing bending near the support, which produced a stress of up to 2000 lb. in.<sup>2</sup> The applied deflections can be made to vary from 1/hr. up to 700/min.—R. L. B.

**Criterion of Static and Fatigue Failures.** A. Sniderman (*Proc. Soc. Exper. Stress Analysis*, 1947, 5, (1), 26-30).—The problem of predicting allowable stresses for parts subjected to combined static and fluctuating loads, with emphasis on evaluating conditions leading to static or fatigue failure, is analysed fundamentally.—R. L. B.

**American Apparatus for the Measurement of Strain and the Control of Fabrications.** W. Soete (*Rev. Soudure*, 1946, 2, (1) 3–12).—A detailed account of American techniques for the estimation or measurement of strain, including the use of electric and magnetic strain-gauges, lacquers, and photo-elasticity; both elastic and plastic strains are considered.—F. A. F.

**Improved Techniques and Devices for Stress Analysis with Resistance Wire Gauges.** W. V. Bassett, Helen Cromwell, and W. E. Wooster (*Proc. Soc. Exper. Stress Analysis*, 1946, 3, (2), 76–88).—By using a mercury-pool connector, electrical contact is established directly with strain-gauges. This device improved strain-gauge procedure during a welding-stress investigation on Liberty and Victory ships to find the cause of weld failures. In order to increase confidence in the results, as inconsistent stress values had been discarded as unreliable, the sources of error were considered at each stage of the technique. Strain-gauge electrical instruments and the final calculated stress were capable of absolute check, and thence the remaining variants could be identified. By a rigid procedure of standardization, the strain-indicator reading was accepted as a reliable indication of gauge response. The design and applications of the mercury connector are described, and procedures for calculating the stresses from rosette data by means of an averaging calculator and a geometrical computer are explained. Typical examples in the determination of principal stress and axial stress are appended.—R. L. B.

**Allowable Working Stresses.** G. C. Noll and C. Lipson (*Proc. Soc. Exper. Stress Analysis*, 1946, 3, (2), 89–101; discussion, 102–109).—Adequacy in the design of material in its fabricated form must be achieved through a balance between the working stresses and the allowable stresses. The past concept of design utilizing tensile or yield stresses in conjunction with a factor of safety, being applicable for static stresses only, is inadequate to comply with the repetitive or alternating stresses encountered in automobiles and aircraft. Consideration was given to the determination of allowable working stresses, resulting in the development at the Chrysler Corporation of methods using stress-relationship diagrams. General conditions of stress were studied, and for stress-estimation purposes the diagrams are specified according to Brinell-hardness ranges for material having ground, machined, hot rolled, or as-forged surface conditions. The five steps necessary in applying the method in practice are detailed, and in conclusion it is admitted that important factors, e.g. nitriding, carburizing, and induction hardening, &c., are not allowed for and that some degree of unreliability persists because of the necessity for extrapolation, but that the endurance determinations were based on “unlimited life” tests (usually  $10^7$  cycles).—R. L. B.

**Photo-Grid Strain Analysis of [Aluminium Alloy] Formed Parts.** George Gerard (*Proc. Soc. Exper. Stress Analysis*, 1946, 3, (2), 110–120).—Analytical and experimental studies were carried out on formability because of the introduction of high-tensile heat-treated aluminium alloys for use in aircraft. The limited ductility of 24S-T8 in particular limited its forming properties. The investigation utilized the photo-grid method in a fundamental survey of the elongation characteristics of test specimens, coupled with a geometrical strain analysis of formed parts. Correction factors were applied in determining simple tension to account for multi-axial stresses, and variables affecting the results were specimen thickness, grain-size (which is largely dependent on heat-treatment), and grain-direction effects. Strains in bending are analysed for plain and clad material, as is also the bending induced in joggle tests.

—R. L. B.

**Residual-Stress Indications in Brittle Lacquer.** C. W. Gadd (*Proc. Soc. Exper. Stress Analysis*, 1946, 4, (1), 74–77).—Brittle lacquer can be used for quickly surveying a structure or component for residual stress. The location,



direction, and qualification of the stress(es) can be determined by the pattern of the cracks produced. A hole  $\frac{1}{8}$  in. dia. and  $\frac{1}{16}$ – $\frac{1}{8}$  in. deep is drilled in the test surface after allowing the lacquer to dry hard. The part may then have to be cooled to help the pattern develop. Illustrations of simple and biaxial tensile-, compressive-, or shear-stress patterns on actual components are shown. Any stress induced during drilling was found to have a negligible effect on the pattern.—R. L. B.

**Brittle-Lacquer Stress Analysers.** C. W. Smith (*Paint Manuf.*, 1947, 17, (10), 333–338).—The essential characteristics of brittle-lacquer coatings for determining the distribution of surface strains are described. Such lacquers may be used on ferrous and non-ferrous metals as well as on non-metallic materials. They are applicable to both static and dynamic tests, including tensile, bending, shearing, vibrational, impact, and fatigue tests, and are particularly suitable for the experimental analysis of surface strains on objects of complicated shape where the normal methods cannot be applied owing to space limitations. The lacquers are very useful in design work, where the most highly stressed areas on prototypes can quickly be determined and the design modified accordingly. They may also be used for detecting hidden surface flaws.—G. T. C.

**Stress-Analysis Utilization in Dynamic Testing.** Roy W. Brown (*Proc. Soc. Exper. Stress Analysis*, 1947, 4, (2), 42–51).—Simplified and co-ordinated stress-analysis and dynamic tests of experimental structures reduce development time and cost. The several new instruments described and illustrated make possible further improvement in experimental analysis. The development of a new aircraft undercarriage is used as an example necessitating analysis of both metal and rubber compounds. Systematic collection of service data by the user is strongly urged as a necessary supplement and guide to better utilization of available experimental stress-analysis methods.

—AUTHOR.

**Stress Measurement by Electrical Means.** Robert E. Kern and Sidney B. Williams (*Elect. Eng.*, 1946, 65, (3), 100–106).—The theoretical considerations of, and the experimental techniques of using, electrical strain-gauges are ably discussed under two main headings: the mechanical problem, and the electrical problem. A number of useful formulæ connected with stress and strain calculations and their relationship with strain-gauge data are given.

—J. B. C.

**Flaw Detection Without Destruction.** — (*Instrument Practice*, 1947, 1, (10), 374–381).—Two supersonic flaw-detecting instruments are described in detail, the method of testing and principle of operation being discussed. Some advantages are pointed out, and notes on applications are given.—P. L.

**\*Replica Method for Roughness Measurement.** R. Smoluchowski (*Res. Sci. Instruments*, 1946, 17, (8), 309).—A thin layer of a solution of cellulose in acetone or of Formvar in ethylene dichloride containing a dye is applied to the cleaned surface. Before it dries, a piece of cellulose tape is pressed on and later stripped off. The tape is thus covered with a replica of thin and thick areas, with enhanced contrast if a dye is used, and may be photographed, studied under a microscope, or examined with a light beam and photo-cell. The method is especially useful for studying curved surfaces and those not readily accessible.—J. C. C.

**Plastic Replicas for Surface-Finish Measurement.** J. Pearson and M. R. Hopkins (*J. Iron Steel Inst.*, 1948, 158, (1), 138).—P. and H. describe a method, developed in the B.I.S.R.A. laboratories, for the preparation of plastic replicas of metal surfaces, which may be employed for roughness measurements by stylus instruments. A drop of a homogeneous mixture of monomeric and polymerized methyl methacrylate, containing a photochemical catalyst and a stripping agent, is placed on the metal surface. 2

piece of Perspex is placed over the drop and pressed down. The specimen is then irradiated with ultra-violet light for 1 hr., during which period the liquid is cured. The replica is then removed from the specimen. P. and H. present results of Talsurf records, taken on specimens and their replicas, which show that faithful reproduction is achieved.—R. W. R.

**Tentative [A.S.T.M.] Method of Test for Peel or Stripping Strength of Adhesives (D903-46T).** — (*Book of A.S.T.M. Standards, 1946, (III B), 1213-1216*).

**The Application of Projection to Inspection.** S. W. Holden (*Instrument Practice, 1947, 1, (3), 104-107*).—With the trend in recent years of aero-engine design demanding a greater machining accuracy on profiles, &c., inspection departments have had to find methods for accurate and speedy means of checking. H. describes the projector, by means of which the outline of a part is cast as its magnified shadow, which may be super-imposed on to a large drawing. Methods are described by which the profile may be projected even when the shape of the part prevents the passage of the light beam.

—P. L.

### RADIOLOGY

**The Peak of Development of German X-Ray Technique.** W. Köhler (*Arch. Metallkunde, 1946, 1, (1), 3-9*).—An illustrated description is given of the development, during 1939-45, of German X-ray equipment, including fine focus and hollow anode tubes, using 120-200 kV., suitable for the examination of thick-walled light-metal components and of small parts.—E. N.

**\*A New Stereoscopic X-Ray Apparatus.** H. Lüscher (*Arch. Metallkunde, 1946, 1, (1), 9-10*).—The construction, operation, and applications are described.—E. N.

**The Evaluation of X-Ray Back-Reflection Diagrams.** F. Regler (*Arch. Metallkunde, 1946, 1, (1), 11-14*).—Methods for calculating lattice dimensions from X-ray back-reflection diagrams on flat, cylindrical, wedge, and ring films, with and without the use of standards, are described.—E. N.

**\*A Semi-Cylindrical Camera for Determining Small Changes in the Lattice Dimensions of Crystals by X-Rays.** F. Günther (*Arch. Metallkunde, 1946, 1, (1), 14-16*).—G. describes the construction, operation, and applications of the camera.—E. N.

**\*A Contribution to the X-Ray Determination of Lattice Constants and Stresses in Coarse Crystalline Materials.** F. Lihl (*Arch. Metallkunde, 1946, 1, (1), 25-31*).—The usual methods of measuring the internal stresses of materials from X-ray back-reflection patterns introduces difficulties and errors due to the necessity for using specimens of small grain-size in order to produce sharp diffraction rings. In the new method, which enables coarse-grained specimens to be used with the consequent production of spotted rings, the average distance of a number of single spots ( $\sim 50$ ) from a standard gold ring is measured. This enables shifts of  $\pm 0.03$  mm. to be determined.

—E. N.

**Contribution to the Question of Villiard [Pulsating] Voltage or Direct Voltage for Technical Radiographic Apparatus.** H. Verse (*Arch. Metallkunde, 1946, 1, (1), 32-36*).—V. discusses the application of direct-voltage radiographic outfits to the examination of parts having large cross-sections.—E. N.

**X-Ray Testing and Progress in Casting Technique.** H. Reininger (*Arch. Metallkunde, 1946, 1, (1), 37-38*).—The types of faults in castings which can and cannot be determined by radiographic methods, the X-ray equipment necessary, and the resulting improvement in casting technique, are described.

—E. N.

**\*A Radiographic Appraisal [of the Use] of Chaplets Coated with Tin and Tin Substitutes.** H. Reininger (*Arch. Metallkunde, 1946, 1, (1), 39-48*).—E. N.

**Radiography has Role in Developing Foundry Practice.** Rober G. Waite (*Foundry*, 1947, 75, (9), 134).—The advantages of radiographic examination of pilot castings are stressed.—R. W. R.

**X-Ray Inspection Promotes Casting Quality Control.** E. H. Grimm (*Foundry*, 1947, 75, (10), 94–96, 130, 133, 136).—G. considers, in a general way, the assistance afforded to the foundryman by the use of X-rays, particularly for the examination of pilot castings.—R. W. R.

**Tentative [A.S.T.M.] Methods of Radiographic Testing of Metal Castings (E15–39T).** — (*Book of A.S.T.M. Standards*, 1946, (IA), 1092–1096).

**Tentative [A.S.T.M.] Industrial Radiographic Terminology for Use in Radiographic Inspection of Castings and Weldments (E52–45T).** — (*Book of A.S.T.M. Standards*, 1946, (IA), 1097).

**Automatic Measurement of Sheet-Metal Thickness by X-Ray.** H. Seymour (*Petroleum*, 1947, 10, (3), 68–69).—A method developed by G.E.C. (U.S.A.) of automatically measuring the thickness of metal strip as it comes from the rolls is described. Details are given of a suitable arrangement of apparatus. Two beams from an X-ray tube are used and their intensity compared on two detectors after one of the beams has passed through the unknown strip and the other through a strip of standard thickness.—G. T. C.

**Recent Contributions to the X-Ray Method in the Field of Stress Analysis.** J. T. Norton and D. Rosenthal (*Proc. Soc. Exper. Stress Analysis*, 1947, 5, (1), 71–77).—Includes a *bibliography* of 18 references.—S. G.

**A 2,000,000-Volt X-Ray Installation.** Lovell Cardenas (*Iron Steel Eng.*, 1947, 24, (12), 89–96; discussion, 97–99).—C. describes the construction of the tube, control panel, and auxiliary equipment and its performance. It is particularly applicable to high-density alloys, e.g. gas-turbine forgings, and for the inspection of highly stressed areas. A few representative radiographs are reproduced.—M. A. V.

#### XIV.—TEMPERATURE MEASUREMENT AND CONTROL

**Thermo-Electric Temperature Measurement.** G. H. Talbot (*Instrument Practice*, 1947, 1, (7), 265–270).—The principles and application of thermo-electric temp. measurement are discussed. A table of types of thermo-couples is given, including details of platinum/platinum-rhodium, Chromel/Alumel, and iron/Constantan couples. Several metallic and refractory sheaths are mentioned.—P. L.

**High-Temperature Pyrometry.** N. R. Holbrook (*J. Junior Inst. Eng.*, 1947, 58, (3), 65–72).—Describes the design, construction, and applications of instruments for measuring high temp. in industry. H. considers that for fixed installations where high temp. have to be measured and controlled, the total-radiation pyrometer is most suitable, and that when portability is necessary and in laboratory work where high precision is required, the disappearing-filament pyrometer is undoubtedly the best.—S. G.

**Standard Specifications for A.S.T.M. Thermometers (E1–46).** — (*Book of A.S.T.M. Standards*, 1946, (IIIA), 713–715, tables, 716–729).

**Tentative Specifications for A.S.T.M. Thermometers (E1–46T).** — (*Book of A.S.T.M. Standards*, 1946, (IIIA), 1208–1210; tables, 1211–1218).

**Fundamentals and a Few Technical Terms Dealing with Automatic Temperature Control for Industrial Purposes.** Noel Retlaw (*Instrument Practice*, 1947, 1, (10), 381–386).—After discussing some of the basic principles of automatic temp. control, R. gives a brief summary of technical terms.—P. L.



## XV.—FOUNDRY PRACTICE AND APPLIANCES

**\*Effect of Iron and Silicon Impurities on the Tensile Properties and Heat-Treatment Characteristics of Sand-Cast Aluminium-10 per cent. Magnesium Alloy Test Bars.** R. T. Parker, (Miss) G. M. L. Cox, and A. N. Turner (*J. Inst. Metals*, 1946, **73**, (4), 175-196; discussion, (12), 757-759).—It has been observed in the past that, under commercial conditions, sand-cast test bars of aluminium-10% magnesium alloy have variable tensile properties, these variations occurring both within and between groups of bars cast from different melts. In the investigation described, the differences between test bars prepared from the same melts of the alloy were almost eliminated by careful foundry technique, those remaining occurring only with metal of greater impurity content. To explain the differences between melts, groups of D.T.D. test bars were cast in dry sand from melts containing 0.10-0.75% iron with 0.10-0.50% silicon. It was found that, while an increase of iron has a slightly beneficial effect, an increase of silicon drastically reduces the ultimate tensile strength and elongation. The proof-stress value is slightly increased with increasing total impurity content. The optimum tensile properties of an alloy containing 0.10% iron and 0.10% silicon appear to be approx. 25 tons/in.<sup>2</sup> ultimate tensile strength and 35% elongation on 2 in., these values being obtained from test bars solidified under an air pressure of 100 lb./in.<sup>2</sup> A comparison of low- and high-purity aluminium-10% magnesium alloy test bars under varying heat-treatment conditions showed that the high-purity alloy is much the more sensitive to differences in solution time and temp.—AUTHORS.

**\*Note on the Effect of Dissolved Gas on the Hot Tearing of Aluminium Casting Alloys.** D. C. G. Lees (*J. Inst. Metals*, 1947, **73**, (8), 537-540).—Following earlier work, which showed that the hot-tearing tendencies of degassed aluminium-base casting alloys were mainly determined by their eutectic contents, tests were made to ascertain the effect of dissolved gases, which are known to have a significant effect in practice. The limited evidence presented indicates that the presence of dissolved gas tends to minimize hot tearing, but the effect appears to be less important than that of eutectic content.—AUTHOR.

**Aluminium Alloy Castings [—II].** Floyd A. Lewis (*Foundry*, 1948, **76**, (1), 94-98, 171-172, 174-175, 178).—Cf. *Met. Abs.*, this vol., p. 361. L. describes the chemical composition, physical properties, nomenclature, and applications of the principal aluminium casting alloys, classifying and discussing them under the following headings: general-purpose alloys, architectural and decorative alloys, corrosion-resistant alloys, alloys for use at elevated temp., piston alloys, bearing alloys, and miscellaneous alloys.

—R. W. R.

**Aluminium—Casting Developments in Review.** Walter E. Sicha (*Foundry*, 1948, **76**, (1), 70-73, 124, 126).—A survey of progress made in the founding of aluminium since the end of the war.—R. W. R.

**\*A Study of Aluminium Casting Alloys Containing Copper and Silicon.** Bollenrath and Gröber). See p. 396.

**The Casting of [Manganese-Brass] Hatch Covers in Partly Chilled Moulds.** L. M. Soskin and N. S. Tokarsky (*Sudostroenie*, 1947, (1), 18-19).—[In Russian]. Describes the method used to cast covers 750 cm. in dia. × 8 cm. thick, weighing 67 kg., in a copper alloy containing zinc 40 and manganese 3.5%.—N. B. V.

**Brass and Bronze—Casting Developments in Review.** Walter W. Edens (*Foundry*, 1948, **76**, (1), 78-81, 121).—A review of recent progress made in the casting of copper-base alloys.—R. W. R.

**Phosphor Copper and Phosphor Bronzes as Used in the Manufacture of Wire and Strip.** C. P. Bernhoeft (*Wire Ind.*, 1946, 13, (152), 445-448).—The production of 10% phosphor copper by adding yellow phosphorus to copper scrap packed round a perforated copper tube in a graphite crucible at 550°-600° C. is outlined. The calculation of melting charges for phosphor-bronze founding is described. High-quality phosphor-bronze wire is said to be drawn from spiral strip 0.216 × 0.216 in. cut by a special shear from spun-cast discs 1½-2 ft. in dia. cold-rolled from 0.5 to 0.216 in. in thickness.

—J. C. C.

**Gas and Shrinkage in Tin Bronzes.** E. F. Tibbetts (*Foundry*, 1947, 75, (9), 74-77, 164, 168, 170, 172, 175).—A general discussion of shrinkage and gas unsoundness in bronzes. T. describes the radiographic appearance of unsoundness and its effect on mechanical properties and pressure-tightness, and considers measures for its prevention. The effect of the freezing range of the alloy on the type of unsoundness is discussed; shrinkage in long-freezing-range alloys takes the form of microporosity, while short-freezing-range alloys tend to localized shrinkage.—R. W. R.

**Casting Artistic Bronzes.** Pat Dwyer (*Foundry*, 1947, 75, (11), 66-71; (12), 96-99, 125, 128).—A description of practice at a foundry making statues and other artistic bronze castings.—R. W. R.

**\*Effect of Chills on Rate of Solidification of Gun-Metal.** William J. Richmond (*Foundry*, 1947, 75, (10), 72-73, 252, 254, 256).—R. describes experiments made to determine the effect of chills in steel and other materials on the solidification of a plate 2 × 6 × 6 in. cast in 88-8-4 gun-metal. The chills studied, which were of various thicknesses, formed one of the 6 × 6 in. faces of the sand mould. The rate of skin formation in the chilled region of the casting was found by bleeding a series of castings at suitable intervals after pouring. The effect on the skin formation rate of variation in the casting thickness in the range 2-½ in. was also examined. Curves are presented in which the skin thickness is plotted against time after pouring, for various combinations of chill thickness and material; chill thickness is also plotted against the time at which bleeding became impossible, for different casting thicknesses and two pouring temp. (1100° and 1150° C.). R. concludes that: (1) on the basis of equal chill vol., the materials examined are in the following order of decreasing chilling power: steel, graphite, carbon, sand; (2) steel chills are to be preferred for bronze on account of their relative indestructibility; (3) in a plate casting, the chill thickness need only be ¼ to ½ the casting thickness; and (4) after the initial chilling, the cooling effect of a chill is dependent on heat transfer to the mould.—R. W. R.

**\*A Comparison of Test-Bar Designs Cast in 85-5-5-5 Alloy.** L. W. Eastwood and J. G. Kura (*Foundry*, 1947, 75, (8), 76-81, 226, 228, 230, 232, 234).—Cf. *Met. Abs.*, this vol., p. 398. In an examination of the ability of 11 different designs of test bar to assess the quality (gas content) of copper-base alloys, numerous bars in each design were poured, under standardized conditions, in 85-5-5-5 leaded gun-metal. The sensitivity of the different bars to metal quality was studied by pouring each in metal of varying gas content; metal of 4 qualities (excellent, good, fair, and poor), obtained by the use of different melting procedures, was employed. The effect of pouring temp. was also examined in each instance. The tensile-test results obtained from the bars are presented both graphically and in tabular form. E. and K. conclude that melt quality is reasonably satisfactorily assessed by only the following 4 designs: (1) the horizontal ⅝-in. web Webbert bar, (2) the Navy ⅝-in. web Webbert bar, (3) the L.T.B. bar, and (4) the Navy ⅝-in. web Crown bar. The other bars, which include the D.T.D. bar, were all rejected either on account of low results or for insensitivity to metal quality. None of the bars (including the acceptable ones) could differentiate clearly.

between melts the qualities of which showed only fairly small differences. The authors point out the need for a standardized test-bar procedure; a factor of particular importance is a standard mould material on account of the possibility of gas absorption from the mould, which might affect the properties of the bar.—R. W. R.

**\*Effect of Pouring Temperature on Test-Bar Properties of 85-5-5-5 Alloy.** L. W. Eastwood and J. G. Kura (*Foundry*, 1947, **75**, (9), 86-88, 175, 178-179).—Cf. preceding abstract. Experiments to determine the effect of pouring temp. on the properties of various designs of test bar cast in 85-5-5-5 leaded gun-metal are described. Five designs of test bar were studied; these were the modified  $\frac{5}{8}$ -in.-dia. web Webbert bar and the four designs shown, in previous work, to possess reasonable sensitivity to metal quality (the horizontal  $\frac{5}{8}$  in. web Webbert, the L.T.B.-2, the Navy  $\frac{5}{8}$ -in. web Webbert, and the Navy  $\frac{5}{8}$ -in. web Crown bars). Bars of each design were poured at various temp. in the range 1100°-1230° C. from 30 melts of 85-5-5-5 alloy; these 30 melts were prepared in triplicate, using 10 different melting techniques which produced substantial variations in metal quality. The results obtained are presented as graphs showing for each bar the variation, with pouring temp., of the ultimate tensile strength and elongation; separate curves are given for bars poured from metal of high and low quality. Figures are also given, for each design of bar, for the percentage of bars found to contain (a) dross inclusions and (b) fractures outside the gauge length. The following conclusions are reached: (1) ultimate tensile strength generally increases with decreasing pouring temp., this increase being most marked with metal of low quality; (2) with metal of low quality, percentage elongation generally increases with decreasing pouring temp.; (3) with metal of good quality, the percentage elongation is a maximum at an intermediate pouring temp.; this effect is rather erratic; (4) the idea of an optimum pouring temp. for a particular design of bar should be abandoned, since the effect of this factor depends markedly on melt quality; and (5) dross defects increase markedly with decreasing pouring temp., while shoulder fractures increase with decreasing melt quality; the latter are most prevalent in the Webbert-type bars.—R. W. R.

**\*Effect of Mould Material on Gas Absorption by 85-5-5-5 Alloy.** L. W. Eastwood and J. G. Kura (*Foundry*, 1947, **75**, (10), 86-91, 156, 158, 160, 162).—Cf. preceding abstract. After a brief review of previously published information relating to the reaction between copper-base alloys and the mould into which they are cast, and to the resulting gas absorption, experiments are described in which the effect on this phenomenon of a number of variables was investigated. Test bars of 4 different designs (the horizontal  $\frac{5}{8}$ -in. web Webbert, the modified  $\frac{5}{8}$ -in. web Webbert, the modified  $\frac{5}{8}$ -in. web Crown, and the keel block) were cast in moulds prepared in various ways; a range of pouring temp. (1100°-1300° C.) and different melt qualities were employed. The moisture content of naturally bonded sands and the permeability of both natural and synthetic sands were found to have little effect on the properties of the test bars. Both the bonding material in the sand and the mould-baking temp. were found to exert considerable influence, best mechanical properties being obtained with synthetic-sand moulds baked at 927° C., with green natural sand next. Determination of the percentage of voids in the horizontal  $\frac{5}{8}$ -in. web Webbert bars revealed the following order: (1) synthetic sand baked at 927° C. (assumed 0.0% voids), (2) green synthetic sand (1.3% voids), (3) natural sand, green (1.8% voids), (4) synthetic sand, baked at 232° C. (2.2% voids). Bars poured in calcined clay moulds bound with mono-ammonium phosphate and magnesium oxide and baked at 232° C. gave low properties and were unsound, while other bars poured in similar moulds baked at 871° C. gave high properties; the unsoundness



produced in the moulds baked at 232° C. is accounted for by the reaction:  $2\text{NH}_3\text{MgPO}_4 \cdot 6\text{H}_2\text{O} \longrightarrow \text{Mg}_2\text{P}_2\text{O}_7 + 2\text{NH}_3 + 7\text{H}_2\text{O}$ , the moisture thus produced subsequently reacting with the metal with the production of nascent hydrogen, which is absorbed by the casting. E. and K. present a large amount of data with regard to the effects of the different variables on test-bar properties. By means of cooling curves it was demonstrated that the effects observed could not be accounted for by differences in the rates of solidification in the different moulds. High-phosphorus alloys are more subject to gas absorption from the mould on account of destruction of the protective oxide skin by the phosphorus. Moulds baked at 232° C. give lower casting properties than do green moulds because, in the latter, the bulk moisture assists in the formation of a protective oxide skin; gas absorption is largely due to the combined water in the bond. The effect of gas absorption from the mould in relation to the function of a test bar as a measure of metal quality is discussed, and it is concluded that, to ensure reproducibility, test bars should be cast in moulds completely dehydrated by baking at 871° C.

—R. W. R.

**\*Reliability of Test-Bar Properties as a Measure of the Quality of 85-5-5 Alloy Melts.** L. W. Eastwood and J. G. Kura (*Foundry*, 1947, 75, (11), 94-99, 168).—Cf. preceding abstract. The concluding article in the series. E. and K. describe further tests carried out on the four designs of bar shown to have reasonable sensitivity to metal quality. These bars were: the horizontal  $\frac{5}{8}$ -in. web Webbert, the L.T.B., the Navy  $\frac{5}{16}$ -in. web Webbert, and the Navy  $\frac{5}{8}$ -in. web Crown. Each of the above bars was poured from 49 melts, the qualities of which varied owing to the use of different melting procedures; three pouring temp. (1219°, 1162°, and 1108° C.) were employed. All the moulds were in green sand. The ultimate tensile strength and elongation figures obtained from each pair of bars were plotted against the weighted average figure obtained from all the bars of all the designs poured from the melt concerned; in determining the average figures, greater weight was given to bars poured from the higher temp., since such bars are more sensitive to variation in gas content of the melt. While all the test-bar designs revealed clearly the inferior quality of the three worst melts, the remainder of the melts were not placed in precisely the same order of merit by the four different designs of bar. It is suggested that the discrepancies observed may be due to gas absorption as the result of metal/mould reaction. It is concluded that melts cannot be reliably accepted or rejected on the basis of the properties of a single bar, or even of two bars cut from the same casting. The following specification is suggested for test-bar practice: (1) a single specific design should be employed, (2) green sand of moisture content 6-6.5%, A.F.A. permeability of 20-40, and green strength 6-8 lb./in.<sup>2</sup> should be used, and the moulds should be rammed to a hardness of 55-60; (3) the moulds should be poured from 4 in. above the pouring basin, and the downgate should be kept full; (4) the pouring temp. should be kept const. within  $\pm 14^\circ \text{C}$ .; (5) each inspection lot should be represented by 4 bars, the mean properties of which should be above the specified figure; and (6) an inspection lot should be defined as the castings poured from 1000 lb. of metal.—R. W. R.

**Gases Causing Unsoundness in Copper-Base Alloys.** (Eastwood and Kura). See p. 398.

**\*Some Mathematical Considerations and Experiments Concerning the Shape of Pipes in Ingots.** E. W. Fell (*J. Inst. Metals*, 1947, 73, (5), 243-262).—The object of the research was to analyse the shape of pipes formed in a mass of substance on freezing. Pipes are due to contraction in vol. during freezing under gravity. The horizontal top surface of the liquid in a pipe is sensitive to the vol. changes during freezing, and since the pipe depends on the position of this liquid surface, it acts as a recording dilatometer.

Pipes thus afford information, which appears otherwise unobtainable, about the process of solidification in the molten mass. A natural pipe is the result of numerous influences, which makes the subject complicated. There are, for instance, the effects of differential crystallization when the substance is a mixture, of motion in the liquid during solidification, and of the state of aggregation of the solid formed, as well as the external cooling conditions at the surface of the mass in the mould. In spite of these and other difficulties, broad inferences are possible, but it would be unwise to regard the present paper as other than introductory. An interesting part of a pipe is that formed near the end of freezing, where the "shell" hypothesis breaks down. In the production of natural pipes whose shape it is required to analyse, it is most important to ensure known and const. conditions over the outer surface of the mould. The shapes of pipes in an upright and finite cylindrical block when cooling proceeds (a) from the vertical sides only and (b) from the vertical sides and a flat bottom, are determined mathematically, and a comparison is made with natural pipes formed in aluminium alloys. Interest arises in relation to the interdendritic-flow theory of inverse segregation. The position of the solid/liquid interface in a finite cylindrical block of aluminium, cooling from the vertical sides and flat bottom, is determined mathematically. Further assumptions are made for simplicity. Periodic variation of the surface of pipes, and pipes and cavities formed by freezing of masses of spherical shape, are considered.—AUTHOR.

**Selecting Proper Pattern Equipment.** Ray Olsen (*Foundry*, 1947, 75, (9), 93, 215–216).—A brief discussion.—R. W. R.

**Plastic Patterns [in the Foundry].** E. J. McAfee (*Metal Ind.*, 1947, 71, (21), 419–421).—Reprinted from *Amer. Foundryman*, 1947, 12, (1), 26–31; see *Met. Abs.*, this vol., p. 163.—J. L. T.

**Plastic Patterns [for the Foundry].** Robert H. Herrmann (*Foundry*, 1947, 75, (7), 89, 232–233).—A brief account of the use of phenol-formaldehyde resin for pattern production.—R. W. R.

**Conditions Affect Choice of Moulding Method.** Pat Dwyer (*Foundry*, 1947, 75, (8), 82–83, 222, 224, 226).—D. discusses the various factors affecting the method of moulding to be employed and illustrates his remarks by considering alternative procedures for moulding a flanged ring casting 36 in. in dia.—R. W. R.

**On the Nature of the Clayey Binding Medium in Mould Sands and Its Significance for Foundry Technology (A Review of Recent Work).** K. Endell (*Arch. Metallkunde*, 1947, 1, (2), 57–63).—E. N.

**\*A Colloid-Chemical Theory of Inorganic Binders in Moulding Sands.** H. Reininger (*Arch. Metallkunde*, 1947, 1, (2), 63–73).—Colloidal chemical and physical effects are exerted on the sand by the clayey binder material both when the water is added and when it is removed, and this enables the principal properties of permeability and strength to be varied. Experiments with various binders show that those having a high degree of swelling give the best results.—E. N.

**Core-Binding Agents.** H. Hüttenes (*Arch. Metallkunde*, 1947, 1, (2), 74–76).—A review.—E. N.

**\*On the Simultaneous Use of Inorganic and Organic Binders [in Moulding Sands].** L. Jeníček (*Arch. Metallkunde*, 1947, 1, (2), 76–83).—Superior permeability and strength in moulding sands can be obtained by the use of properly proportioned mixtures of inorganic and organic binders.—E. N.

**Methods and Apparatus for the Examination of Moulding and Core Sands.** L. Jeníček (*Arch. Metallkunde*, 1947, 1, (2), 83–94).—J. reviews the customary methods for determining moisture, density and mouldability, gas permeability, shear and compressive strengths, and resistance to abrasion. A new method for determining the last property is described.—E. N.

**\*Heat Absorption of Moulding Sand.** Harry W. Dietert, Edward J. Hasty, and R. L. Doelman (*Foundry*, 1947, **75**, (9), 84-85, 228, 230, 232).—The authors describe the results of measurements of the apparent thermal conductivity of rammed specimens of moulding sand. Two sands, one coarse and one fine, were studied, both being bonded with 4% bentonite. The results obtained are presented as graphs showing the variation of apparent conductivity with temp. in the range 90°-1350° C. Above 400° C. the apparent conductivity increases rapidly with temp., this increase being most marked for the coarse sand; the conductivity of this sand is trebled in the temp. range considered. Conductivity was also found to increase with increase in grain-size and density of the sand.—R. W. R.

**Determining Sand Moisture by Electrical Instrument.** Charles Locke and Fred De Hudy (*Foundry*, 1947, **75**, (8), 180, 182).—A description of an instrument which determines the moisture content of moulding sands by measuring their electrical conductivity. The device is stated to be superior to that recently described by Liddiard and Seal (*Foundry Trade J.*, 1946, **80**, 257; *Met. Abs.*, 1947, **14**, 25) in that the sample is rammed to a fixed degree by a steel spring; this considerably improves the reproducibility of the results.

—R. W. R.

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## XXV.—BOOK REVIEWS

**Bibliography of the Platinum Metals, 1918–1930.** By James Lewis Howe and Staff of Baker and Co., Inc. Imp. 8vo. Pp. 138. 1947. Newark, N.J.: Baker and Co., Inc., 43 Astor St. (\$5.00.)

About the end of the first World War, Dr. Howe published his well known bibliography of the platinum metals covering the years 1748–1917. This is a continuation of that work for the years 1918–1930 inclusive and arranged in the same way, i.e. the references are arranged alphabetically according to author each year. In making this compilation, Dr. Howe has had the assistance of the technical and library staff of the well known American refiners and workers of platinum, Baker and Co., Inc.

To begin the book there are 173 additional entries to the first Howe bibliography, and these are followed by 3825 entries spread over the 13 years covered by the book. Every entry not only gives the reference to the original journal of publication but also to one abstract journal, usually *Chemical Abstracts* or *Chemische Zentralblatt*, but occasionally to *British Chemical Abstracts* or *Journal of the Institute of Metals*. There is a comprehensive subject index but no author index, owing to the difficulty of transcribing Russian names, which occur with great frequency and in a variety of spellings, depending on the abstract source from which the reference was taken.

This is a useful compilation to all who are interested in the platinum metals, and we look forward to the next volume covering the years 1931–1940 inclusive, which is promised for this year.—A. R. POWELL.

**Essential Metallurgy for Engineers: The Causes and Control of Metallic Properties.** By A. C. Vivian. With an Introductory Preface by Professor R. S. Hutton. Second edition. Demy 8vo. Pp. xi + 155, with 33 illustrations. 1945. London: Sir Isaac Pitman and Sons, Ltd. (8s. 6d. net.)

This is a *most* exasperating book, not because it is bad, but because so many of the blemishes, of which there are a lot, some of them serious, could so easily have been eliminated. To take two typical examples, one from the beginning and the other from the end of the book, it is stated on p. 3 that "There is comparatively little in a microscope view of a metal which can be interpreted usefully as causes of the properties". If this be so, then those of us who have been waiting for years for more microscopes, which manufacturers are unable to supply, are fortunate: we shall now have plenty of time to cancel these before they are delivered. Which of the German writers was it who said that "what a man does not understand he despises"?

In dealing with the first edition of this book, the reviewer directed attention to the quite erroneous diagram given for the brasses, in which the  $\beta$  phase is shown as breaking down at 470° C. into an  $\alpha/\gamma$  eutectoid (see *Met. Abs.*, 1943, 10, 132). This diagram is still published, on p. 120, as well as in Fig. 25, and if the foot-note "N.B. This is sometimes described as  $\beta'$ , another solid solution different from  $\beta$ " was added to meet the reviewer's criticism, this just adds insult to injury. Why the author insists that sorbite has a laminated structure passes the wit of man to understand. On p. 66 the author says quite properly "tempering temperatures must all be below the critical range". In Fig. 16, however, under the heading of "Structural Changes During the Tempering Operation", he includes pearlite. Further, this pearlitic area is marked as being "visible under the microscope". The student, therefore, may quite reasonably believe that the sorbitic area, not so labelled, is a structure which is microscopically irresolvable. It is just this sort of thing, which is found almost throughout the book, which is so unsatisfactory and so unnecessary.

The title of the book is "Essential Metallurgy for Engineers". If the contents represent knowledge which is essential to that profession, there are few engineers in this country.

—F. C. THOMPSON.

**The Rare-Earth Metals and Their Compounds.** By Don M. Yost, Horace Russell, Jr., and Clifford S. Garner. Med. 8vo. Pp. ix + 92, with 9 illustrations. 1947. New York: John Wiley and Sons, Inc. (\$2.50); London: Chapman and Hall, Ltd. (15s. net).

In recent years the rare-earth group of metals has once again become a centre of interest, not only from the practical point of view but also from that of the nuclear physicist, for many of the members of the group are found among the products of nuclear fission. The discovery during the last ten years of convenient methods of reducing three of the earths to the divalent state and better methods of oxidizing two of the others to the quadrivalent state has incited chemists to turn their attention again to the many fascinating problems which the



chemistry of these metals presents. Recently some success has been obtained in America in devising methods of separating the earths by ion-exchange columns, and Dr. Marsh at Oxford has made many advances in chemical methods of separation. Metallurgists have also commenced to explore the possibilities of the metals as alloying constituents; cerium "Mischmetall" has been used for some time as a constituent of magnesium alloys, and Losana and his collaborators in Italy and Germany have investigated many binary systems of the commoner rare-earth metals (cerium, lanthanum, praseodymium, and neodymium) with copper, silver, gold, magnesium, aluminium, lead, and tin. Ceria has also been used successfully in industry as an opacifier for enamels, as a delustrant in artificial-silk manufacture, as a catalyst in organic syntheses, and, more recently, as a polishing powder for optical glass. Nevertheless, a large field remains to be explored, and future research may indicate many other spheres of usefulness of these metals and their compounds.

If the book under review serves no other purpose than to whet the appetite of the research student to adventure into this fascinating field it will have justified its publication. It can be said at once that it will serve as a useful introduction to the subject, especially to those who are more interested in the fundamental physical problems associated with the structure of matter. There are only six chapters, dealing with, respectively, electronic structures and oxidation states of the rare-earth elements, paramagnetic properties of their compounds, absorption spectra, evidence for the existence of element 61, methods of separating the rare earths, and the chemical and physical properties of the rare earths. Appendices contain information on the nuclear properties of the rare-earth elements and general physical constants; there is also a table of the Periodic System.

The physical sections appear to be very well done, but the chemical chapters are too brief to give more than a general survey of the more important chemical properties and behaviour of the metals and their compounds, and to indicate in general terms methods of tackling the complex problems associated with the separation of the earths from their naturally occurring mixtures. Most of the few inaccuracies noted in the book occur in this section; the "phosphate" method of Marsh alluded to on p. 41 should read "dimethylphosphate", and the further note about this method on p. 47 is not only misleading but misses the whole point of the method, which is that the yttria-group dimethylphosphates are very soluble in ice-cold water but much less soluble in warm (50° C.) water, as shown in the table on p. 42, so that on warming the cold solution the compounds crystallize out. Double nitrates of the yttria group (yttrium and elements 66-71 inclusive) are not formed as stated in the table on p. 59. High-purity samaria can now be obtained in good yield by the sodium-amalgam method of Marsh, which is not mentioned in the book.

Despite these few defects the book can be thoroughly recommended to all those wishing to acquire an acquaintance with what still remains the most difficult and interesting field of inorganic chemistry.—A. R. POWELL.

**Applied Elasticity.** By John Prescott. Demy 8vo. Pp. [v] + 666, with 182 illustrations. 1946. New York: Dover Publications, 1780 Broadway. (\$3.95.)

What is a reviewer to write of a book first published in 1924 and now reproduced from the original edition by a lithographic process? Is he to remark that each page is completely in focus? It is; that the new binding is superior to the old? so it is; or is he to attempt to criticize a book from which he himself acquired most of his own knowledge of the subject? Rather let him fall back on the last resort of the reviewer and quote from the preface. "In writing this book I have tried to see the subject from the point of view of the engineer rather than the mathematician." So opens the preface, and in 1924 that was a most encouraging opening to those who had tasted only Love. "One important departure from strict mathematical theory is to be found in the use of approximate methods of solution based on the principle of minimum energy"; and later "the method [of minimum energy] is ideal for dealing with problems on stability". So the preface goes on to epitomize one of the chief advances in technique which Prescott achieved. It is true that these methods were already outlined in Love's "Mathematical Theory" and that they have since been developed more thoroughly, notably by Timoshenko. It is true also that Prescott, despite his advocacy, yet undervalued the energy method in deeming it appropriate only to approximate solutions. Yet his exposition of the method provided a firm foundation upon which others have since built, and in the field of large-deflection theory, which includes the class of problems of instability, few now would use any other approach.

In respect of large-deflection theory, for which in the expression of the strains in terms of the displacements second-order terms need to be included, Prescott may claim even more definitely to have pioneered. Probably his work had been to some extent anticipated by Timoshenko and his Russian associates; but in 1924 this work was quite inaccessible to the English-speaking world, and the very possibility of elaborating small-deflection theory logically to include the membrane stresses was scarcely recognized.

So much for the merits of the work; what of its faults? In parts the exposition, addressed

always to the engineer, appears tedious; Prescott seems at times to hesitate to add 2 and 2 to make 4 in case that process should savour of mathematics. A like tendency is noticeable in the derivation of the elements of the subject, both in the early chapters and again later in the analysis of large deflections. Yet by comparison, Love in this respect is no more concise, so that the criticism less concerns Prescott's style than his epoch. Presumably under the tutelage of these writers we have since learned to decide more instinctively how far mathematics may be trusted.

Another more serious criticism of the work is that Prescott fails to point a clear line of attack. Usually, save, of course, in exposition of the energy method, he proceeds by solution of the differential equation of equilibrium; but stresses, strains, displacements, and even loads bedeck the pages in an almost Love-like profusion, so that the reader is sometimes left in awful wonder at the author's unerring instinct for the one essential symbol to hunt through each particular covert. With Timoshenko, later generations are learning to exercise greater economy of means, and it is apparent that the process of pruning needs to be carried a good deal further.

What more remains to be said? Excepting Timoshenko's series, no two works on elasticity adhere to the same notation. Perhaps Prescott may be blameworthy for helping to establish this bad tradition; but in fact his notation is in many ways superior to those which preceded it. The scope of the book is not wide: five chapters on the elements; six mainly on rods and beams, but including torsion; four on flat plates, including one on large deflections; two on spheres and cylinders; one on rotating discs; and one on contact. But Prescott is on our shelves not for what he does but rather for the way he does it, and that presumably is the aspect of the work which has recommended it for re-publication.—H. L. Cox.

**Aluminium and Its Alloys.** By N. F. Budgen. Second edition. Demy 8vo. Pp. ix + 369, with 150 illustrations. 1947. London: Sir Isaac Pitman and Sons, Ltd. (25s. net.)

In the first edition of this well known book the author set out to cover the technology of aluminium in all its aspects and to do this in a manner which would make the volume acceptable to readers with little technical training. In the volume now under review the earlier work has been brought up to date.

The developments which have taken place over the past few years have necessitated the re-writing and expansion of the greater part of the book; revision has been thoroughly carried out and most of the recent technical advances seem to be touched on in the new edition. Roughly one-third of the total space is devoted to matters connected with the extraction of the metal and the remainder to chapters on alloying, casting, working, heat-treatment, welding, corrosion, surface treatment, and the application of the metal to practical use.

If one accepts that there is a call for books on aluminium of the "popular" type, then the present volume may be adjudged successful; it certainly contains a great deal of useful information and will undoubtedly prove of interest and value to non-specialist readers. The book was not primarily written for metallurgists, and there are a number of features which make it desirable that the serious student should use it with caution.

The writer's main criticism falls on Chapter VI, in which the properties of the various alloys are reviewed. Values for ultimate stress, proof stress, elongation, and hardness are given for a large number of compositions; the reader who attempts to assess the relative merits of different alloys on the information given, however, may well go astray. In most cases the values quoted are "typical" values, but in a number of instances specified minima are included. No clear distinction is in general drawn between the representative and the specified values, and there is an inclination to "write up" the "typical" values for the mechanical characteristics (particularly the proof stress) unduly.

There is an error in the section on heat-treatment; the low-temperature heat-treatment of alloys such as R.R. 50 and Alpax Beta does *not* improve ductility. In the same chapter the recommended method for avoiding grain growth in wrought products is to "limit the amount of cold work between successive anneals to a reasonable amount and to shorten the annealing time to the absolute minimum". Reference might usefully have been made to the grain growth arising from *insufficient* working of the metal, which is much more likely to be encountered.

Some of the statements in the section on pressure die-casting are a little odd, and it is difficult to accept "aeration of the metal" (by contact with compressed air) as the principal cause of unsoundness in pressure die-castings made on a gooseneck machine. It is hoped that manufacturers of cold-chamber pressure die-castings will not be too greatly embarrassed by customers asking why the castings supplied to them were not (as stated in this book, "denser than those poured by gravity"). The statement that castings "can be heat-treated without difficulty to give fully improved mechanical properties" should also not be taken too literally; the ordinary aluminium-silicon alloy which is in general use for pressure die-castings does not respond to thermal treatment, and few die-casters would accept orders for castings which involved annealing at anything other than low temperatures.



Two slips are noted which may be corrected in future issues; on p. 3 the statement is made that sodium turns aluminium out of its oxide (chloride clearly intended), and on p. 116 the specified value for elongation of the alloy conforming to specification D.T.D. 424 is entered as the Brinell hardness.—R. J. M. PAYNE.

**Los Rayos X y la Estructura Fina de los Cristales. Fundamentos Teóricos y Métodos Prácticos.** (X-Rays and the Fine Structure of Crystals. Fundamental Theories and Practical Methods.) Por Julio Garrido y Joaquín Orland, S. J. Prologo del Don Julio Palacios. Demy 4to. Pp. xiii + 260, with 237 illustrations. 1946. Madrid: Dossat, S.A., Plaza de Santa Ana 9. (148 pesetas.)

The object of this work is to explain the fundamental principles of X-ray diffraction and its use in the determination of the fine structure of solids. The text is divided into three parts; in the first the general principles are discussed in four chapters dealing respectively with the nature and properties of X-rays, the phenomena which occur when an X-ray beam is passed through a solid, the principles and notations of crystallography, and the diffraction of X-rays by crystals. The second part describes the determination of crystal structure by the Bragg, Laue, Weissenberg, rotating crystal, and powder methods, and shows how the crystal lattice, space group, and atomic configuration are calculated from the results obtained. In the third part are given some examples of the results obtained by X-ray crystallography, including the crystal structure of the metals, non-metals, and noble gases; the data on this subject are collected into a useful table showing the physical properties of all the elements, arranged in order of atomic numbers. There is, however, no reference to the use of X-rays in the study of metallic alloys, although characteristic structures of many organic and inorganic compounds are illustrated and described.

The book forms a sound introduction into the science of X-ray crystallography and consequently demands a thorough knowledge of mathematics for its due appreciation. The arrangement of the subject-matter, the clarity of printing and reproduction of diagrams, and the quality of the paper and binding are excellent. Readers in Spain and Latin America have in this book for the first time in their own language a valuable guide to the difficult subject of X-ray crystallography.—A. R. POWELL.

**Métallurgie des Poudres.** By R. Kieffer and W. Hotop. Translated from the German by P. Naslin. 24.5 × 16 cm. Pp. xvi + 391, with 244 illustrations. 1947. Paris: Dunod. (1680 francs.)

**Powder Metallurgy: its Physics and Production.** By Paul Schwarzkopf, in collaboration with C. G. Goetzel, George Stern, Robert Steinitz, and Werner Leszynski. Med. 8vo. Pp. xii + 379, with 164 illustrations. 1947. New York: The Macmillan Co. (\$8.00); London: Macmillan and Co., Ltd. (40s. net).

The first German edition of "Kieffer and Hotop" (under the title of "Pulvermetallurgie und Sinterwerkstoffe") was published in Berlin in 1943, but hitherto only a few lithographed copies, produced in America, have filtered through to this country. The French translation which is the subject of this review has been prepared from the second German edition of 1944; and it may be hoped that an English translation may become available before too long. For this is undoubtedly the best text-book that has yet appeared on powder metallurgy, and it is, further, almost encyclopædic as a work of reference. The authors' professed aim has been to summarize all the most important publications on the subject, to relate the conclusions of other workers to their own observations and experiments, and to set out as completely as possible all that is known on the consolidation of metal powders by pressing and sintering. After a short introduction and a brief review of methods of preparing and testing metal powders, an excellent account is given of what is known of the mechanism of pressing and sintering, followed by a short chapter on hot pressing. The authors incline to the view that sintering is closely allied to recrystallization, but due regard is given to the views of all those who have contributed to the literature of the subject. In the very lucid discussion, three cases are recognized: the sintering of compacts of one constituent, of several constituents in the absence of a liquid phase, and of several constituents in the presence of a liquid phase. It is clearly, however, that no really satisfactory study of the mechanism by which pores are eliminated during sintering has yet appeared. The next section of the book brings together all published work on the characteristics of individual metals (classified according to their position in the Periodic Table) and their alloys. Finally, special chapters are devoted to the refractory metals (tungsten, &c.), cemented carbides, sintered materials for electrical contacts, porous products, magnetic materials, embedded-diamond products, and dental amalgams. The view that the setting of dental amalgams is a special case of sintering in the presence of a liquid



phase is unusual, but logical. The treatment here, however, is very superficial and could with advantage have been much more detailed. Taken as a whole, the book is extremely well-balanced and complete, and is likely to remain the standard work of reference on powder metallurgy for many years. The French translation is excellent, but unfortunately the index present in the original German edition is omitted. There are a few slips in the page references, and some mistakes in the spelling of proper names, and it is to be hoped that these will be corrected in future reprints.

Dr. Schwarzkopf's book is planned on very similar lines, but, although more pretentious, is much less comprehensive. The author claims in his preface that, unlike company employees who "frequently may not or cannot report truthfully and extensively", he has not been "subject to any restrictions regarding the disposal of his knowledge and experience"; but it cannot be said that he reveals any hitherto unrecorded details of technique or presents any original points of view. The first chapter reviews briefly methods of testing metal powders and indicates some of the chief processes by which metal powders are produced. The second chapter, on compacting, and the third, on sintering, include illustrations of some American presses and sintering furnaces, but touch only briefly on operating or design details and could undoubtedly have been expanded, with real advantage, on the basis of the experience of the author and his collaborators. Coining processes are then mentioned, and the first section of the book concludes with a discussion on "inter-relations between powder characteristics, compacting, and sintering conditions" which, touching at the heart of the science of powder metallurgy, briefly summarizes a selection of the literature and provides a reasonably adequate but elementary introduction to the subject. The second, and longest, section of the book is a review of published data on powder-metallurgy products under the heads of Dense Materials, Porous Products, Refractory Metals, Hard Metals, Electric Contact Materials, Magnetic Materials, and Friction Parts. Finally, there is a short discussion of theories of sintering, a note on the importance of diffusion, and a comparison of "the mechanical strength and hardness of sintered metals as compared with those of reguline metals". This latter, barbarous term, of uncertain parentage, is used without apology or explanation throughout the book to mean cast and worked metals; but it is sincerely to be hoped that others will not follow Dr. Schwarzkopf's lead. The volume is well documented, and a lengthy supplement reviews 115 papers which were published after the manuscript had been completed.—J. C. CHASTON.

**Analysis of Aluminium and Its Alloys. Chemical, Colorimetric, and Photometric Methods.** 4to. Pp. 196, with 18 illustrations in the text, 2 plates, and 2 folding tables. 1947. London: British Aluminium Company, Ltd., Salisbury House, London Wall, E.C.2.

This book is a re-written version of the edition which appeared in 1941, and the arrangement of its contents is similar. There is, however, a much more thorough discussion of the statistical treatment of analytical results which has been found to be most useful in the works laboratory for continuously assessing the accuracy and reliability of routine analysis.

Many new and up-to-date methods for the determination of various alloying elements in aluminium alloys are described in detail, and alternative procedures are given for most elements to serve as confirmatory methods. The schemes of analysis based on qualitative analytical group separations given in the earlier edition have now been replaced by tabulations of the direct methods applicable to the determination of each element in the pure metal, since the descriptions of these methods given elsewhere in the book contain the necessary information on essential preliminary separations.

The important position which colorimetric methods now occupy in the routine works laboratory owing to their rapidity and accuracy is recognized by the devotion of 18 pages to a description of the apparatus and technique of this branch of analysis and by the number of different elements for which a colorimetric or absorptiometric method is available. Useful features of the book are the clear line drawings of special apparatus, the details which are given of the standard errors of every method described, and the frequent notes drawing the attention of operators to important details or precautions to be observed.

Although primarily written for those who have to carry out routine analyses of aluminium alloys and materials, there is no doubt that many other metallurgical analysts will find much information in the book of value to them in their own work. The British Aluminium Company are to be congratulated on maintaining this publication at such a high standard in these difficult times, and their technical staff on performing such a valuable service to their colleagues and other firms by keeping the subject-matter so up to date.—A. R. POWELL.

**946 Book of A.S.T.M. Methods of Chemical Analysis of Metals.** Med. 8vo. Pp. x + 402. 1946. Philadelphia, Pa.: American Society for Testing Materials, 1916 Race St. (\$4.50.)

This book, a new edition of which appears approximately every three years, contains the current standard A.S.T.M. methods for the analysis of ferrous and non-ferrous metals

and alloys, both those formally adopted and those still in the "tentative" stage. Photo-metric and polarographic procedures appear for the first time, and spectrographic methods are also included. The subjects covered comprise: apparatus and reagents; methods of sampling; analysis of steel, cast iron, open-hearth iron, wrought iron, and ferro-alloys; and analysis of aluminium and aluminium-base alloys, magnesium and magnesium-base alloys, copper, brass and bronze, pig lead, lead- and tin-base alloys, silver solders, zinc, nickel, and electric heating and resistance alloys. The Committee responsible for developing the method has made every effort to keep the methods up to date and to take advantage of shorter procedures which have been developed in recent years. The result is that this book may be considered as an authoritative source of rapid, reliable, and accurate methods for the control of production and for use in buying and selling ferrous and non-ferrous metals and alloys.

One of the most useful features of the book is the description with illustrations of all the most important pieces of apparatus and set-ups required for metal analysis, e.g. potentiometric apparatus; distillation trains for the determination of arsenic and antimony, nitrogen (as ammonia), chromium (as chromyl chloride), and sulphur (as hydrogen sulphide and as sulphur dioxide); apparatus for polarographic analysis; internal-electrolysis cells; Jones reductor; and mercury cathode cell. Detailed information is also given on the preparation of standard solutions and non-standardized reagents.

Every analyst should add a copy of this book to his library; the cost is reasonable, the procedures are described lucidly and in great detail, and the paper, printing, and binding are excellent.—A. R. POWELL.

**Metal-Working and Heat-Treatment Manual. Volume II.—Alloy Steels, Cast Iron, and Non-Ferrous Metals.** By F. Johnson. Demy 8vo. Pp. 226, with 74 illustrations. [1947.] London: Paul Elek Publishers, Ltd., Diamond House, 37-38 Hatton Garden, E.C.1. (17s. 6d.)

This little manual is concerned with the heat-treatment of the alloy steels, cast iron, and the non-ferrous metals. By far the larger portion deals with the steels, there is one chapter concerned with cast iron, one on the general heat-treatment of the non-ferrous metals, and one on age-hardening. The general treatment is simple, factual, and reasonably complete so far as the alloy steels are concerned. The treatment of cast iron is much less comprehensive, and the space allotted to the non-ferrous metals and alloys does little more than skim the surface. The treatment of age-hardening is, however, quite good and gives a very satisfactory general picture of the effect in ferrous and non-ferrous metals alike. This chapter is, within its limits, one of the best general statements available in any ordinary text-book. As an example of the author's efforts to make the treatment really up to date may be mentioned the detailed consideration of the age-hardening of the copper-beryllium alloys and its relation to the diagram of that system.

With the observation that the treatment of the cast irons and the ordinary non-ferrous metals is somewhat scrappy, it may be said that the remainder of the book is a very creditable presentation of the subject-matter which can be recommended to those students who are mainly concerned with the facts.—F. C. THOMPSON.

**The Metallurgist Johann Conrad Fischer, 1773-1854, and His Relations with Britain.** Imp. 8vo. Pp. 53, illustrated. 1947. Schaffhausen, Switzerland: G. Fischer, Ltd. (n.p.)

This memoir, issued in English by the firm founded by J. C. Fischer at the beginning of the last century, describes the career of an active and able metallurgist who may be regarded as the father of the Swiss metal industry. It was in 1804 that he produced the first crucible-cast steel on the Continent, although Huntsman, in England, had invented his process in 1740. Unlike Huntsman, however, Fischer did not submit his iron to the preliminary process of cementation, but carburized it directly in the crucible.

The long accounts of Fischer's visits to England are particularly interesting. His first visit was in 1794-95, during his apprenticeship, when he worked with an engineering fitter in London. From 1814 onwards he visited this country eight more times, and he records with pleasure the warm welcome that he received from such men as James Watt and Michael Faraday, who opened their laboratories and workshops to him. This short but well produced and illustrated memoir describes the close relations which he maintained with British scientific men and industrialists.—C. H. DESCH.